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Report for 1951

EXPERIMENT STATION COMMITTEE

A black and white photograph serves as the background for the entire page. It depicts a biplane in flight, positioned in the upper half of the frame. The aircraft is flying over a vast field of sugarcane, which fills the lower half of the image. In the far distance, a range of mountains is visible under a clear sky. The overall tone of the photograph is sepia or aged black and white.

**HAWAIIAN
SUGAR PLANTERS'
ASSOCIATION**

COMMITTEE IN CHARGE

Hawaiian Sugar Planters

THE EXPERIMENT STATION

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*Spraying Cane
with Nu-Green*

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Association

To The President and Members

Gentlemen:

Your Committee takes pleasure in submitting the report of the Director of the Experiment Station, Hawaiian Sugar Planters' Association, for the year 1951. It is hoped that you will find this record of the fruitful results of an aggressive research program in our cane sugar industry both interesting and inspiring.

This year we have added certain new phases to our research program, while restricting those which have given insufficient promise of success. Some of the events and developments of note this year are set forth below.

The surplus lands of the quarantine station at Mapulehu, Molokai, were sold.

The Hilo Sugar Plantation Company's clubhouse was purchased to serve as the headquarters of the Hawaii Substation.

Preliminary discussions with Australian sugar cane growers at the meeting of the International Society of Sugar Cane Technologists in Queensland a year ago, and a reconsideration of our Samoa Substation, led to an agreement with the Colonial Sugar Refining Company to test our promising cane varieties for susceptibility to Fiji disease and to downy mildew in Fiji. Once these arrangements were completed, the need for the HSPA Substation in Samoa for testing the susceptibility of cane varieties to Fiji disease was eliminated. Steps are now being taken to close out this station by selling the buildings and land, and it is hoped that this will be accomplished by February, 1952.

The Meteorology Department, carried jointly by the Pineapple Research Institute and the HSPA, has been expanded to study the possibilities of seeding warm clouds to induce rainfall. The substances used successfully in the super-cooled clouds of the mainland have not proved effective in the warm clouds of the Islands. In the special study, the Territorial Cattleman's Council is giving full cooperation and support, and a committee, made up of representatives from the three organizations, is being appointed to coordinate this phase of the work of the Meteorology Department.

A year ago the By-Products Committee was formed as a subcommittee of the Experiment Station Committee for the purpose of exploring the possibilities of increasing the income of the Hawaiian sugar industry through development of new uses for sugar cane by-products. At that time, the HSPA had received a grant from the Industrial Research Advisory Council of the Territory to install a hydropulper at Waipahu to separate the pith from the fiber of sugar cane bagasse in order to develop marketable stock feeds. By the middle of the summer the project had shown sufficient promise to warrant its full activation to study the possibilities of making paper products as well as stock feed from bagasse. Mr. George Aljian was borrowed from the California and Hawaiian Sugar Refining Corporation to coordinate the project, and funds were authorized by the Executive Committee for one year to finance a program which will be abandoned at the end of that time if it does not show sufficient promise. In this first year, primary emphasis will be placed on development of an economic and satisfactory separation of pith from fiber of the cane bagasse.

Hawaiian Sugar Planters' Association

As this report is being written, the Director of the Experiment Station and the Chairman of this Committee are in Peru inspecting a successful paper-from-bagasse industry there.

We would like to acknowledge our appreciation for the interest and attendance of the Island members of the Experiment Station Committee, who have done much to bring the work of the Station closer to immediate problems on the individual plantations. This Committee would also like to commend the work of the Agricultural Engineering Committee, the By-Products Committee and the Factory Engineering Committee in forwarding the scientific research of the Station in their particular fields of endeavor.

We are proud to present this report from Dr. Baver and the members of the Experiment Station staff, as we feel that the accomplishments of the past year are testimony of a research program which should be the cornerstone of a secure future for the Hawaiian sugar industry.

Respectfully submitted,

EXPERIMENT STATION COMMITTEE, HSPA

W. W. G. MOIR, *Chairman*
J. D. BROWN

R. A. COOKE, JR.
F. W. BROADBENT

W. M. BUSH
G. E. SCHAEFER

Associate Members

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R. M. ALLEN

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WALTER E. SMITH

FREDERICK SIMPICH, JR.
A. R. GRAMMER, *Secretary*

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Agricultural Engineering Committee

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J. D. BROWN
R. A. COOKE, JR.
L. A. McDONELL

Associate Members

L. S. McLANE
R. C. WILLIAMSON
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E. B. HOLROYDE
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F. A. SCHAEFER III

Associate Members

A. F. WULFEKUHLE
J. T. ORRICK
G. W. TOMPKIN
C. D. CHRISTOPHERSON
L. D. BAVER

By-Products Committee

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W. W. G. MOIR
G. E. SCHAEFER
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A. L. DEAN
R. A. COOKE, JR.

Associate Members

H. J. W. TAYLOR
A. E. FAYE
A. A. KRUSE
R. JOHNSTON
L. D. BAVER

To the Experiment Station Committee

Gentlemen:

Submitted herewith is the annual report for the year ending September 30, 1951.

The research program of the Station has been focused on the fundamentals of the major problems affecting the sugar industry.

In line with this emphasis, Dr. John N. Warner of the Department of Genetics was sent to New Guinea and Australia to look for promising wild canes and to familiarize himself with the breeding programs of the Colonial Sugar Refining Company and the Bureau of Sugar Experiment Stations of Queensland.

The Department of Agronomy has been stressing soil improvement, correct placement of fertilizers in the soil, foliar application of fertilizers, more scientific approaches to irrigation, and the adaptation of crop logging to the entire industry. A full-time man has been employed to aid in a study of crop logging and its application to different areas. The spectroscope has given valuable information on problems pertaining to fertilization.

The Department of Physiology and Biochemistry is cooperating closely with other departments in the use of radioactive techniques for evaluating the efficient distribution of both fertilizer and water under practical field conditions. New approaches to the physiology of the plant from the standpoint of plant analysis have been undertaken to help increase the sensitivity and accuracy of the crop log.

The Department of Chemistry has been keeping abreast of the actual and potential shortages of herbicides, and has procured information on substitutes that promise to continue, or even to increase, the efficiency of weed control operations. Contacts made with mainland soil testing laboratories promise to put RCM analyses of both soils and plants on a more rapid and exact basis.

The efforts of the Department of Agricultural Engineering have resulted in the development of a direct-mounted harvester for unirrigated cane, a cane cleaner for removing shorts from trash at the mill, a rotary hoe for the incorporation of trash into the soil, and an experimental infield transportation unit for wet areas. The harvesting of cane by the side-mounted cutter-windrower shows strikingly improved ratoon conditions wherever it has been used.

The major activities of the Department of Sugar Technology have been centered around two projects: a six months' study of Elguanite at the Koloa Mill, made in cooperation with C and H Refinery and Grove Farm, and absorbing the activities of several men; and the pilot plant which is being operated at the Oahu Sugar Company to separate the components of bagasse for the production of livestock feed from the bagasse pith and molasses.

The Experiment Station has assumed an aggressive role in by-product research during the year. Bagasse fiber, which is separated from bagasse pith in the pilot plant at the Oahu Sugar Company, is a matter of keen interest because of its importance as a possible source of pulp for the manufacture of paper and paper products. The Director made a trip to the Mainland in October to follow through on previous discussions with the Northern Regional Research Laboratory at Peoria, Illinois, the Institute of Paper Chemistry at Appleton, Wisconsin, and the Forest Products Research Laboratory at Madison, Wisconsin. Recommendations that a By-Products Advisory Committee be appointed to study the problem from the economic point of view were adopted and the Chairman of this Committee, Frederick Simpich, Jr., made further investigations on his subsequent trip to the Mainland. As a result of these contacts and

From The Station Director

studies, the Experiment Station and the Executive Committees approved the appointment of George W. Aljian of C and H Refinery as Coordinator in both the economic and technical phases of the study to explore all possibilities of by-products. Dr. Joseph Atchison, on leave as Chief of the Pulp and Paper Division of ECA, was employed as part-time consultant and spent about six weeks in the Islands. Arrangements were made to cooperate with Dr. E. C. Lathrop of the Northern Regional Research Laboratory on the research phases of the problem.

Plantations have shown increased interest in better experiments, and the newly organized Department of Experimental Statistics is making real progress in helping them to achieve this objective.

The sale of the excess land mauka of the government road at Mapulehu, Molokai, relieved the Station of taxes and upkeep on some 1800 acres of land.

The Hawaii Substation was moved from the inconvenient and poorly housed location mauka of the Hilo Sugar Company to the old Hilo Boarding House just outside the city of Hilo. Here office and warehouse facilities can be so coordinated that the Substation will be of greater service to the island of Hawaii.

Arrangements have been agreed upon by the Hawaiian Sugar Planters' Association and the Colonial Sugar Refining Company of Australia to cooperate in a study of both Fiji disease and downy mildew disease on the island of Viti Levu, Fiji. This new cooperative project will be mutually advantageous to Hawaii and Australia, and will mean the closing of the Samoan Substation early in 1952. The Fiji location will be more accessible to Hawaii, will make it unnecessary to keep a superintendent in residence, and will permit including the study of downy mildew disease in the project. It was learned from Australia that downy mildew is much more of a threat to the Hawaiian industry than is Fiji disease. J. B. Menardi returned from Samoa because of ill health and will assist the Island Representative on Oahu. F. A. Bianchi went to Samoa to supervise the closing of the Substation.

The Hawaiian Sugar Planters' Association, in cooperation with the sugar industries of Puerto Rico, Louisiana, and Florida, has agreed to bear its pro-rata share of the \$5000 necessary to preserve the USDA collection of cane-breeding material at Summit in the Canal Zone. Since the destruction of the Java collection during World War II, the Canal Zone collection is the only fairly complete one in the world, and when insufficient Federal funds threatened its existence, the domestic sugar industries banded together to ensure its continuance.

The Experiment Station temporarily released two of its men for other duties during the year. H. K. Stender, Island Representative on Kauai, was given a year's leave of absence to act as consulting agriculturist to the four Hilo Coast plantations. R. E. Doty, Associate Agronomist and Rat Specialist, was given a leave of absence of approximately three months to assist the Ryukyus Command on the rat control program in Okinawa. Later in the year, Mr. Doty was given a leave of absence to accept the invitation of the sugar cane growers of Mexico to assist in formulating a program of rat control.

The following members of the Station Staff made trips on Experiment Station business during the year:

L. D. Baver—in October 1950, consulted with Dr. Joseph Atchison of ECA, as well as with officials of the Northern Regional Research Laboratory, Forest Products Laboratory, Institute of Paper

From The Station Director

Chemistry, and Crown-Willamette Paper Company, on by-products; presented four papers at the annual meetings of the American Society of Agronomy and the Soil Science Society of America; in March 1951, attended the meetings of the Advisory Committee, Sugar Research Foundation; in the interests of the by-products program, interviewed officials of the W. R. Grace Company, St. Regis Paper Company, Valentine Sugar Company and Louisiana State Univeristy.

George O. Burr—held discussions with Oak Ridge Institute for nuclear studies, and Tracerlab of Berkeley, California, regarding portable Geiger counter sets of higher accuracy; discussed flower induction and inhibitions with officials of the USDA, Cal Tech and UCLA; attended meetings of the Western Section, American Association for Advancement of Science.

F. E. Hance—consulted with officials of Standard Oil Company and Union Oil Company in California on an aromatic oil substitute for critical Diesel oil; made contacts with Boyce-Thompson Institute in New York, Carbide and Carbon Chemicals Company and Dow Chemical Company on SES as a substitute for 2,4-D; discussed substitutes for oil-soluble activator with various chemical concerns; explored the possibilities of CMU as a herbicide with Du Pont; contacted the Soil Testing Laboratory, North Carolina Department of Agriculture, on streamlining the RCM analysis of soils and plant material in the sugar industry.

R. P. Humbert—reviewed research on anhydrous ammonia with Shell Oil Company in California; conferred with research staff of USDA Regional Salinity Laboratory at Riverside on irrigation; discussed soil stabilization and other soils engineering problems with staffs of Rensselaer Polytechnic Institute, Princeton University, Fort Belvoir, and the Military Geology Section of the U. S. Department of the Interior; talked with scientists of USDA on radio-active materials; attended meetings of American Society of Agronomy and Soil Science Society of America.

A. J. Mangelsdorf—presented a paper on sugar cane breeding at the annual meeting of the British West Indies Sugar Association; visited sugar cane areas and research institutions in Cuba, Florida and Louisiana.

J. P. Martin—went to Fiji to arrange for cooperative research on Fiji and downy mildew diseases with representatives of the Colonial Sugar Refining Company.

J. H. Payne—assisted E. C. Gillett at C and H Sugar Refinery in compiling the report on El-guanite; attended meetings of American Chemical Society, International Union of Chemistry, and International Congress on Pure and Applied Chemistry.

The Library added 744 volumes, 106 of which were gifts. Of the 1745 volumes loaned, 318 were borrowed by persons not attached to the Staff. The increased use of the Library by the public was very pronounced during the year.

Staff changes that took place during the year will be found on page 7.

Respectfully submitted,

EXPERIMENT STATION, HSPA

L. D. BAVER, *Director*

Station Personnel Changes in 1951

Joined the Staff

Adachi, Tadaroshi
Amaki, Masukichi
Blanshine, Allison W.
Bond, K. Lyman
Bowman, Ian
Brower, Barbara E.
Budge, Alexander G., Jr.
Cabulong, Ester P.
Carias, Vincent C.
Doty, Wallace L., Jr.
Fairchild, William D.
Hart, Charles W., Jr.
Hart, William E.
Higashiyama, Henry K.
Iwai, Harriet
Iwamasa, Sadaichi
Kawawaki, Yasuhiko
Koga, Ernest
Matsumura, George
May, Charles W., Jr.
Miyashiro, Myrtle
Nakagawa, Charles T.
Neumann, Edwin W.
Nickerson, Lydia C.
Nishibun, Joe
Ogasawara, Edwin T.
Omiya, Yukio
Palmer, Marshall T.
Racca, Guillermo R.
Robinson, Russell S.
Sakai, Richard
Silva, James A.
Spencer, Ernest W.
Trowse, Albert C., Jr.
Vorfeld, Robert T.
Wallis, Charles T.
Yamamoto, Tatsuji

Engineering Draftsman
Pilot Plant Operator
Associate Agricultural Engineer
Assistant-in-Training
Assistant-in-Training
Laboratory Helper
Mechanic-in-Training
Typist-Clerk
Machinist
Assistant-in-Training
Assistant-in-Training
Associate Agricultural Engineer
Assistant Agricultural Engineer
Assistant-in-Training
Typist
Carpenter and Painter
Assistant-in-Training
Office Helper
Laboratory Helper
Assistant-in-Training
Laboratory Helper
Laboratory Helper
Assistant-in-Training
Associate Editor
Laboratory Helper
Assistant-in-Training
Assistant-in-Training
Assistant-in-Training
Janitor
Assistant-in-Training
Mimeograph Operator
Assistant-in-Training
Assistant-in-Training
Associate Agronomist
Assistant-in-Training
Assistant-in-Training
Laboratory Technician

Agricultural Engineering
By-Products
Agricultural Engineering
Training Personnel
Training Personnel
Physiology & Biochemistry
Agricultural Engineering
Oahu Substation
Agricultural Engineering
Training Personnel
Training Personnel
Agricultural Engineering
Agricultural Engineering
Training Personnel
Library
Makiki, Bldgs. & Grounds
Training Personnel
Business Office
Sugar Technology
Training Personnel
Chemistry
Chemistry
Training Personnel
Publications & Visual Aids
Chemistry
Training Personnel
Training Personnel
Training Personnel
Makiki, Bldgs. & Grounds
Training Personnel
Business Office
Training Personnel
Training Personnel
Agronomy
Training Personnel
Training Personnel
Sugar Technology

Left the Staff

Brogren, Roy H.
Gill, William O.
Goto, Herman S.
Gow, Paul
Lanu, Pooai
Melarkey, Daniel C.
O'Day, Shirley
Yates, Phyllis
Young, Calvin J.
Young, David P.
Wehrsigg, Gertrude

Assistant-in-Training
Assistant-in-Training
Painter
Associate Chemist
Night Watchman
Assistant-in-Training
Office Assistant
Associate in Publications
Assistant-in-Training
Assistant-in-Training
Typist

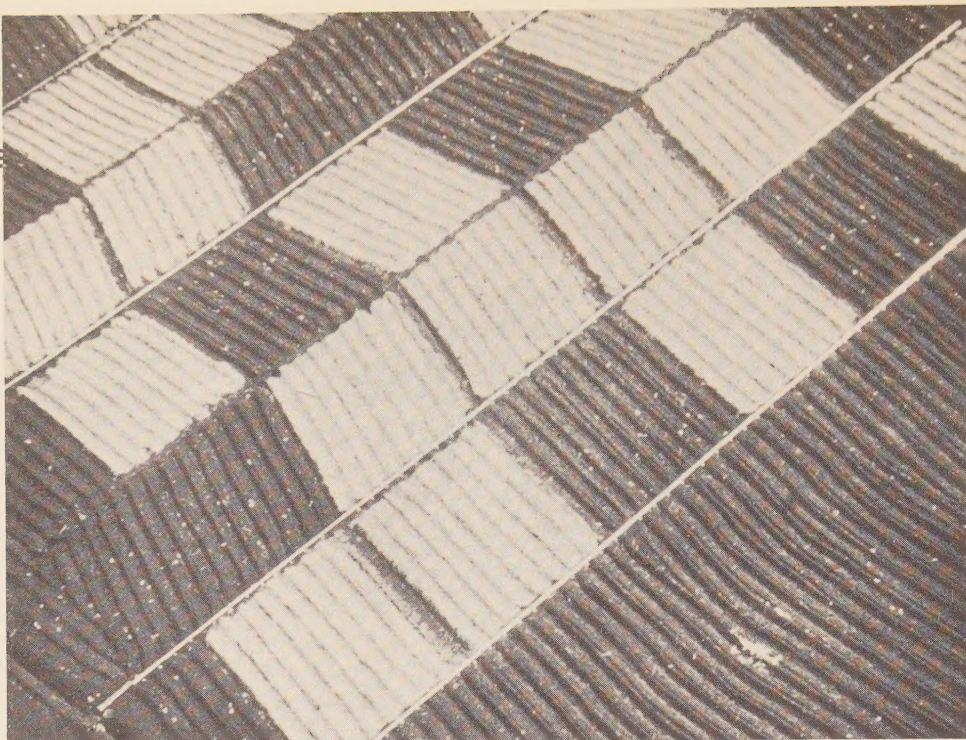
Training Personnel
Training Personnel
Makiki, Bldgs. & Grounds
Chemistry
Makiki, Bldgs. & Grounds
Training Personnel
Oahu Substation
Publications & Visual Aids
Training Personnel
Training Personnel
Library

On Leave of Absence for Military Duty

Ballinger, Donald K.
Nakamura, Robert
Nelson, Victor J.
Palmer, Marshall T.
Sakai, Richard H.
Takakawa, Roy M.
Takajo, Mareo
Tamura, Harold

Assistant-in-Training
Laboratory Assistant
Assistant-in-Training
Assistant-in-Training
Mimeograph Operator
Laboratory Helper
Machinist
Laboratory Helper

Training Personnel
Physiology & Biochemistry
Training Personnel
Training Personnel
Business Office
Publications & Visual Aids
Agricultural Engineering
Chemistry



CULTURAL PRACTICES

TASSEL CONTROL HIGHLIGHTS OF 1951

The following important advances were made in the control of flowering of sugar cane:

- (1) Night lighting can be reduced to 10 exposures between September 1 and 10.
- (2) Exposures on alternate nights are effective.
- (3) Exposures to burning magnesium and aluminum are effective.

These facts represent important advances toward commercial control since the required lighting season is greatly shortened and the quality of light from burning magnesium or aluminum has been proved good. Hence, commercial flares can do the job in case they can be economically handled.

The most extensive yield study has been completed at Ewa Plantation, where their harvests show that plots which flower as much as 35 per cent may lose two to three tons of sugar on a two-year crop. Their experiments have further demonstrated that night lighting does not increase yields except through its effect on flowering. This is a very important observation.

Chemical sprays have marked effects on flowering. Both alpha naphthalene acetic acid, and maleic hydrazide look promising. Sixteen small applications of the former and a single large application of the latter reduced flowering to 20 per cent of the untreated controls.

PLACEMENT OF PHOSPHATE WITH SEED USEFUL FOR EARLY GROWTH

Through a series of radioactive phosphorus studies conducted by the Departments of Agronomy and Physiology and Biochemistry, the advantages of placing phosphate in the subsoil with the seed were clearly indicated.

When it was placed 2½ feet from the lines of cane, the fertilizer was not taken up by the plants during the three months of its radioactive life. Placed one foot from the lines, the fertilizer was taken up after several weeks by only a few shoots, since not all the roots were reached. But when it was placed with the

seed, the fertilizer was utilized immediately. Practically every shoot of every stool showed activity, pointing up the effectiveness of this placement for early growth of the cane plants.

The studies also showed that phosphate applied in irrigation water is so strongly fixed by the surface soil that even after five irrigations, the soil surface is intensely radioactive while the rapidly growing young plant cane exhibits no radioactivity of leaves, stems or growing tips. Therefore, placements within the root zone are essential.

FEEDING LEAVES WITH RADIOACTIVE COMPOUNDS

Under certain conditions, sugar cane may be fed more efficiently through the leaves than through the roots. For instance, it has been found that fixation by the soil of many elements often renders them unavailable to the plant, and that, after the cane has closed in, late applications of nutrients to unirrigated cane can be made only by air.

The Departments of Physiology and Biochemistry and of Agronomy, cooperating in a study of feeding plants by air, have known for a long time that leaves will absorb from solution inorganic trace elements

and organic compounds such as hormones, poisons, sugar, organic nitrogen, etc. In order to make effective air application of nutrients, it is necessary to determine the quantity of a major element that can be introduced through the leaves, its distribution within the plant, and the economics of air application.

The use of radioactive elements has made possible exact knowledge of the plant's rate of uptake, the amounts which can be absorbed, and their distribution throughout the plant. Figure 1 shows that a single

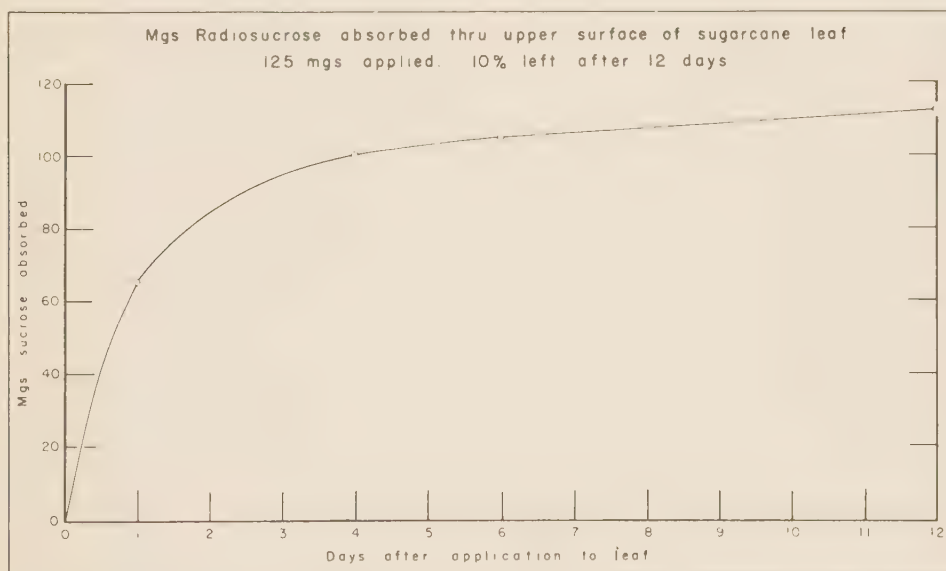


Figure 1. Radioactive elements show how plants use nutrients applied to leaves.

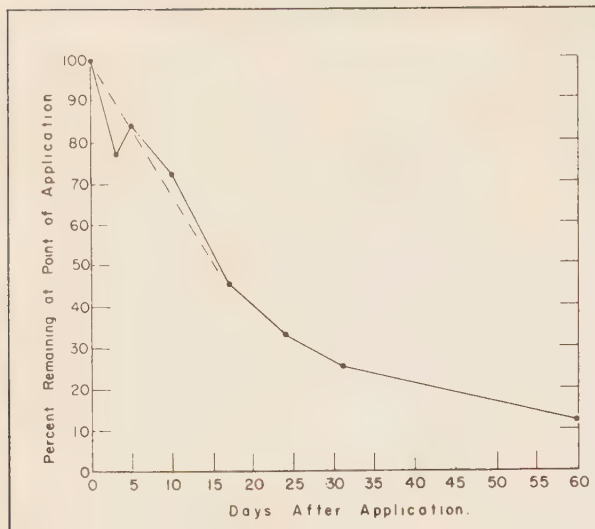
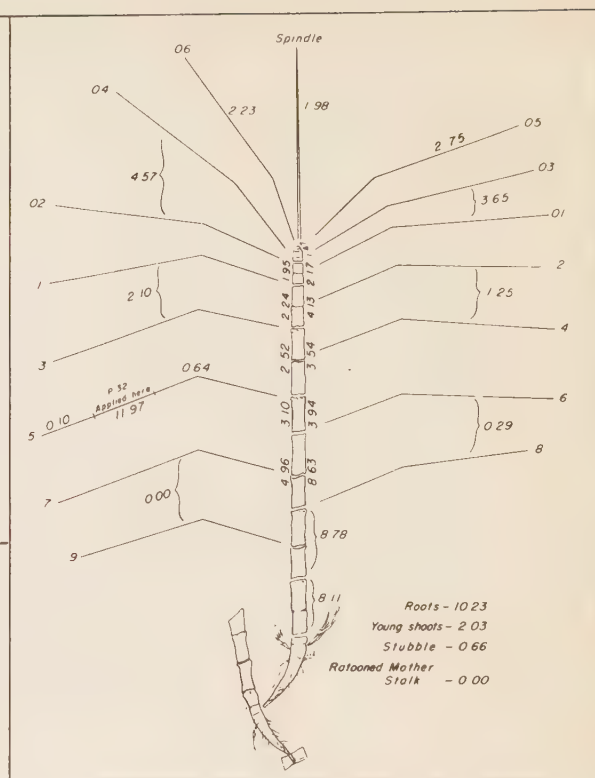


Figure 2. Rate of absorption of potassium and phosphate (P_{32}) applied to leaf surface.

Figure 3. Same plant harvested two months after receiving P_{32} through the surface of leaf No. 5. Numbers give the percentages of the total dose found in the tissue. Leaf blade and sheath were harvested as a unit. Leaves which opened after feeding are numbered 01, 02, etc.



sugar cane leaf can absorb large amounts of radioactive sucrose and that it enters the leaf rapidly and fairly completely, about 50 per cent entering on the first day, with only 12 per cent remaining unabsorbed after 12 days. Figure 2 shows that while potassium acid phosphate, applied to a leaf surface, enters the plant much more slowly than does sucrose, it is well absorbed and becomes generally distributed throughout the plant. Figure 3 shows the same plant at time of harvest, two months after introducing the phosphate through leaf Number 5.

This experiment brought out some interesting points. First, the stalk is shown to be the main storehouse of phosphate. Leaves below the point of feeding retained almost none of the phosphate, while the new leaves and the growing tip were very rich. This bears out the standard observation that after phosphate feeding the growing tip is the hottest spot in the plant, which would indicate that even a little phosphate may do much good if it moves directly into

the tissues which need it most. Recent experiments also indicate a good uptake of phosphate through the sheath when solutions of P_{32} are applied to the dewlap with a dropper. Table 1 shows the movement of P_{32} into new leaves after one month.

Table 1. Counts per minute of new leaves unrolled after applying 100 microcuries of P_{32} (KH_2PO_4) to different dewlaps. Time elapsed between feeding and counting was one month.

Plant No.	No. of leaf to which treated dewlap was attached	Counts per minute	
		Fed dewlap leaf	Spindle plus new leaves
1	1	800	1700
2	2	500	900
3	3	1000	900
4	4	5500	4000
5	6	850	4000
6	8	250	300

PHOSPHATE FERTILIZATION BY AIR

Foliar applications of fertilizer by air, including radioactive materials, have been under critical review by the Departments of Physiology and Biochemistry and of Agronomy. Techniques for spraying the plants with radioactive materials had to be perfected. Figure 4 shows the cages in which the plants are placed for spraying. AEC safety regulations require that these cages be burned and their ashes buried in the radioactive cemetery. After spraying, the plants are charted and checked for activity as soon as new tissues emerge.

Phosphorus applied to the foliage is translocated down the stalks to the secondary shoots. Cane growing in phosphate deficient soils can thus be treated to encourage the development of secondary shoots which are important for early "closing in". Two weeks after being sprayed with phosphate from superphosphate at the rate of eight pounds P_2O_5 per acre, seven-month old cane with only primary stalks developed secondary shoots, thus re-emphasizing the efficiency of foliar applications of fertilizer.

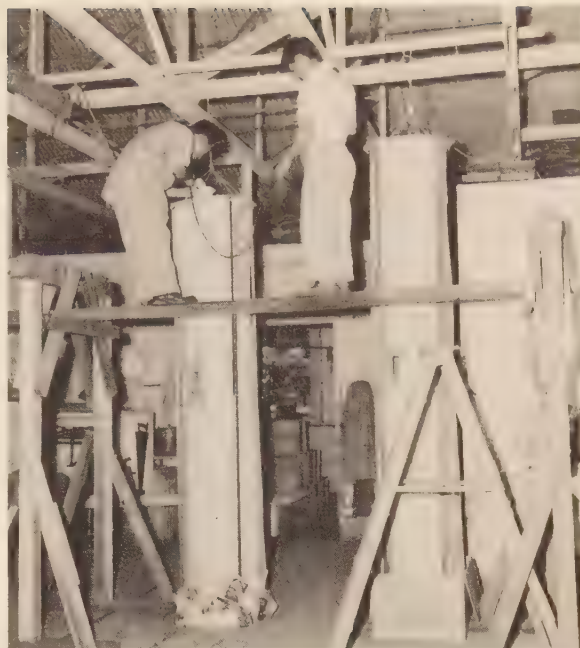


Figure 4. Cane is placed in cages while being sprayed with radioactive materials. The cages are then destroyed in accordance with AEC safety regulations.

RADIOACTIVE STUDIES SHOW HOW CANE USES PHOSPHATE

Study of the distribution of phosphate within the sugar cane plant shows that this element is much more mobile than was formerly thought. When P_{32} is fed directly into the culture solution, radioactivity can be detected well up the stalk within a half hour.

At 1:00 P.M. on August 7, 1950, 1 mc. of P_{32} was added to the culture solution of a large single sugar cane plant. One hour later the material was distributed uniformly throughout the leaves, as shown in Table 2. On August 22, the nutrient was changed to non-radioactive phosphate and the plant continued to grow rapidly until it was harvested on October 3.

Table 2. Counts per minute of blades of cane plant one hour after adding P_{32} to the nutrient solution.

No.	1	Blade (unrolling)	250
	2	"	550
	3	"	450
	4	"	550
	5	"	500
	6	"	650
	7	"	550
	8	"	450
	9	"	350
	10	"	300
	11	"	400
	12	"	350

At time of harvest, the new blades were more radioactive than the old, and recently formed lalas and suckers were as rich in P_{32} as was the parent plant. All of this indicates a pool of phosphate on which the entire plant can draw. The final distribution is given in Table 3.

Table 3. Distribution of P_{32} in a large plant (25 nodes) of variety 37-1933 two months after administering the phosphate. Ordinary phosphate was fed in the interim.

Part	Total Counts	% of Total
Blades (attached)	62,896	9.3
Blades (fallen off)	74,042	10.9
Total Blades	136,935	20.2
Sheaths (attached)	18,337	2.7
Sheaths (fallen off)	27,899	4.1
Total Sheaths	46,236	6.8
Stems—nodes	22,192	3.3
Stems—internodes	262,791	38.9
Total Stems	284,983	42.2
Lalas—stems	8,989	1.3
Lalas—leaves	3,552	5.3
Total Lalas	12,541	6.6
Suckers	109,208	16.2
Stubble	20,355	3.0
Aerial Roots	1,557	0.2
Roots	56,291	8.3
Shoots from Roots	6,260	0.9
GRAND TOTAL	674,369	

TAGGED NITROGEN FOLLOWED IN CANE PLANT

Heavy nitrogen was fed as ammonium sulfate to seven-month-old water cultures of variety 37-1933. 975 mg. of N containing 15 atom per cent of N_{15} were fed to one plant. This was quickly absorbed by the roots. Feeding of the normal culture solution was resumed until good stools had grown.

Leaf punch analyses were made 28 hours after administering the tagged N. The results summarized in Figure 5 bring out clearly the following points:

(1) New N taken up by the roots spreads rapidly throughout the plant in a generalized circulatory stream.

(2) It does not go primarily to regions of low N.

(3) On the contrary, it goes in greatest amount to the leaves richest in N (4, 5 and 6 in this case), probably because these have the highest metabolic activity and the greatest demand for nitrogenous compounds.

After four months of rapid growth on ordinary N, the new suckers were almost as rich in N_{15} as the parent plant. Atom per cent N_{15} in the blades were 0.780 and 0.935 respectively. Complete data on the harvested plant are now being accumulated.

All of the data for tagged N point to the conclusion that N does not become fixed at the place and time of initial utilization, but is continually exchanging with new N. The entire N content of the plant is a pool upon which all parts draw according to their needs and capabilities. These competitive demands determine the concentration found in tissues at any moment.

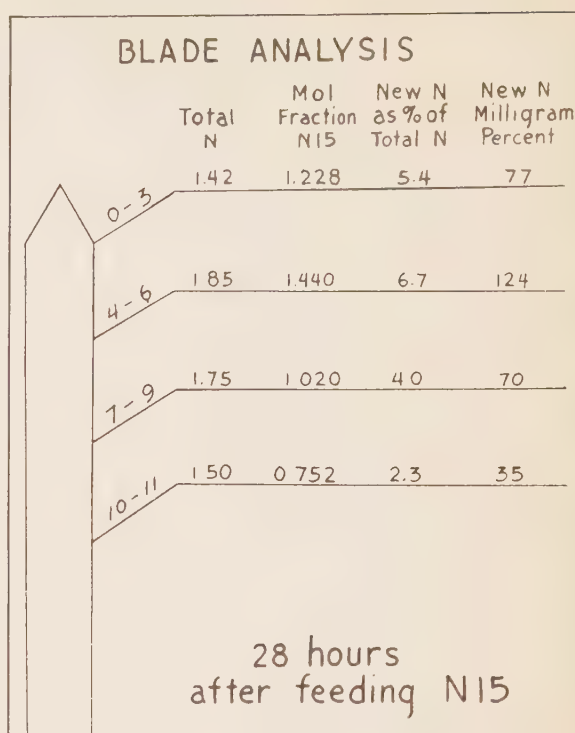


Figure 5. Leaves were analyzed in groups as shown by the numbers on the sheaths. The first column gives leaf blade N by standard leaf punch procedure. The second column gives the Mol fraction of N_{15} , from which is calculated the new N which had entered the leaves during the 28 hours since feeding N_{15} .

CLIMATE AFFECTS NITROGEN UTILIZATION OF CANE PLANT

The portion of the data summarized in Figure 6 from plants cultivated in controlled climate houses brings out the following points:

(1) Plants cultured in high N solution took in from $3\frac{1}{2}$ to $4\frac{1}{2}$ times as much N as those in low N solution.

(2) This is *not* reflected in the leaf punch N. Actually, the ratio of high N to low N is less than 1.

(3) The alcohol soluble N in the upper internodes most nearly reflects the N intake by the plant.

(4) The alcohol soluble N in the lowest internode is most strongly influenced by climate.

There is a strong indication that the gradient of soluble N from base to top is a direct indicator of N demand by the plant.

POTASH FERTILIZATION BY AIR

By means of crop log studies, many areas have been located on several plantations where the soils are unable to supply enough potash (K_2O) to main-

tain the desirable levels in the cane plant. In many instances, sheath K_2O has not been raised to presently accepted standards even by excessive applica-

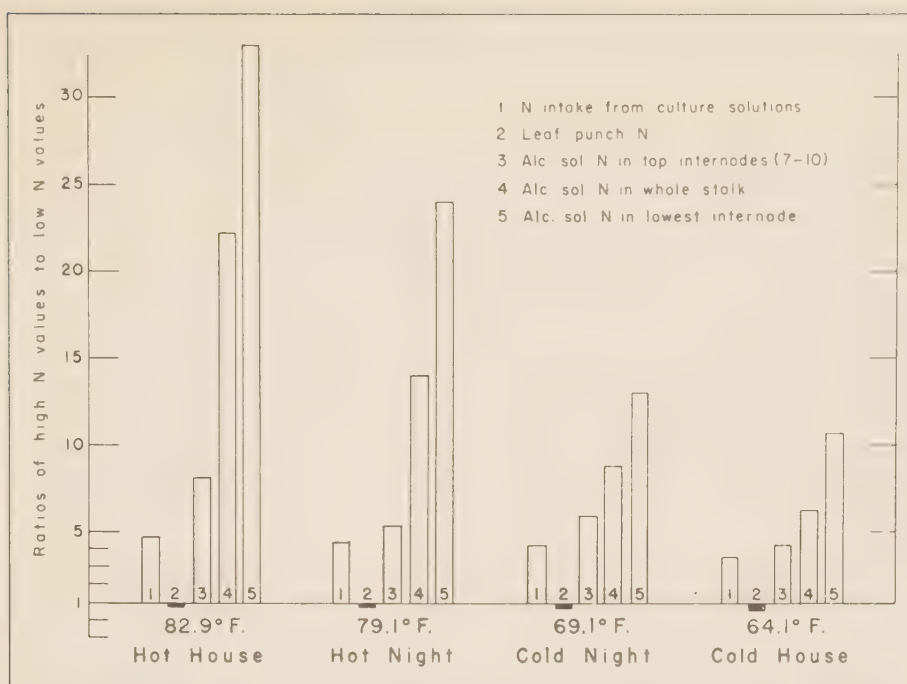


Figure 6. Distribution of N in plants is affected by climate, amount of N fed, and physiological activity of the plant.

tions over and above those which show response in Grade A tests.

Skirmish tests were therefore made to study the effects of feeding the K_2O by air. Oahu Sugar Company conducted the first field test, applying 16.5 pounds K_2O from muriate in 10 gallons of water per acre. Since the cane was adequately supplied with K_2O , the response was small, but there was no burning of the foliage. Kahuku Plantation sprayed K_2O

on cane growing in their heavier, dark-colored soils at the rate of 19 pounds per acre. The response was exceptional, exceeding in most plots the response obtained by the application of 200 pounds K_2O to the soil. Five months after application, the two treatments were at comparable levels of leaf sheath K_2O . Tests made at Ewa, Lihue, McBryde, and again at Kahuku, have produced similar results, and have led to field scale application.

FOLIAR FERTILIZATION WITH UREA

Because the cane plant can be very efficiently fed through its leaves, a new approach to the problems of second season fertilization is possible. After cane has "closed in", as much as 95 per cent of the fertilizer applied by air has been found on the cane leaves, with only 5 per cent on the ground, and preliminary data indicate that small quantities of nitrogen (N) air-applied are fully as effective as larger applications to the soil.

Typical curves of response to the applications of urea by hand and by air are illustrated in Figure 7. The very rapid intake of the N is characteristic where

fields of normally growing cane have been sprayed by air. Analyses of the growing point after applications by air show that the N moves into the plant and is translocated to the new tissues. The cane sprayed by air maintained a higher leaf N percentage for one month, after which there were no significant differences. In cane with greater N deficiency prior to treatment, the sprayed applications maintain their advantage for longer periods of time. Crop log analyses will make it possible to time supplementary air-applications of N accurately, and the rapid rate at which the N is utilized by the plant will permit the

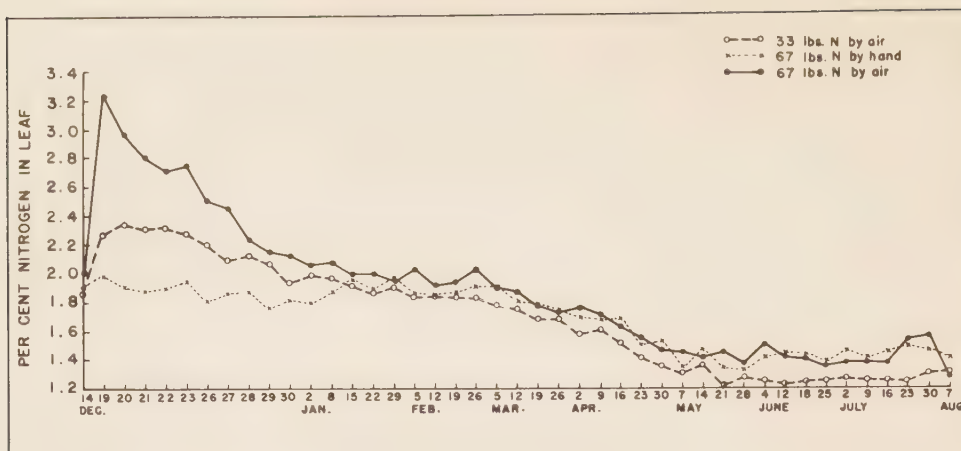


Figure 7. N composition of cane leaves at H. C. & S. following application of urea by air.

scheduling of second season fertilization so that there will be no excesses of N at harvest.

Fertilization studies tend to indicate that a plant and its ratoon crops should receive with the seed all

the phosphorus and from one-third to one-half of the N and potash it will need, and that the subsequent applications of N and potash may be applied by air in accordance with the needs of the plant.

PHOSPHATE RESPONSE OBTAINED ON HILO AND HAMAKUA COASTS

Harvest results have given significant increases in yields of cane and sugar for applications of phosphate in the mauka soils of the Hilo and Hamakua coasts, and have led to an attempt to determine the critical levels of soil phosphorus below which response can be expected. Analyses of check plots from a majority of Grade A amounts-of-phosphate tests have resulted in the establishment of the critical level at 20 p.p.m.

as determined by a modified Truog procedure. The correlation with response to sugar is most promising.

The need for phosphate fertilization should be measured by the available supply of phosphorus in the soil prior to planting, and every effort is being made to increase the sensitivity of the RCM procedure to determine small differences on the low end of the scale.

FORMS OF POTASSIUM FERTILIZER NOT EQUALLY SUBJECT TO LEACHING LOSSES

Laboratory studies on the leaching losses of various forms of potassium fertilizer have been followed by tests with growing plants. A potted Hilo Coast soil was variously treated with equal amounts of potassium in the chloride, sulfate, and two phosphate, forms. Following a substantial leaching with base-free water, nitrogen and phosphorus were added and the pots were planted to Sudan grass.

Analysis of soils and plants at harvest confirmed previous findings and indicated that the leachability of potassium from various forms of fertilizer is as follows:

Most subject to leaching.....potassium chloride
Intermediate.....potassium sulfate
Least subject to leaching....potassium phosphate.

CALCIUM—AN ESSENTIAL ELEMENT FOR SUGAR CANE

Sugar cane is an extremely tolerant plant and is capable of growing in a wide range of pH from acid

to alkaline soils. In soils below pH 5.2, it is possible that calcium is a limiting factor of growth.

In the amounts and forms of phosphate tests at Hakalau, available calcium in the check plots amounted to only 7 p.p.m. Phosphate was the principal limiting factor of growth, and when supplied in the form of ammophosphate had a very good effect

on cane growth until calcium became limiting. Then growth continued in the superphosphate plots but was retarded in the ammophosphate plots, and because significant differences in yields resulted, interest in the liming of acid soils has increased.

WINDWARD KAUAI PLANTATIONS NEED DIFFERENTIAL FERTILIZATION

Seven distinct families of soils are cropped to sugar cane in the windward Kauai region and the variation in the levels of available nutrients is wide. Data derived from the Soil Fertility Survey emphasize forcefully the need to establish plantation fertilization practices for each type of soil on the basis of the supply of available plant food contained in that particular soil.

For the most part, the soils were found to be distinctly acid. Some mauka soils are nearly at the low end of the acid scale, while a few makai irrigated soils are neutral to alkaline in reaction.

ROOTS VARY IN EFFICIENCY IN MOVING NUTRIENTS INTO THE PLANT

Intensive studies of the underground portion of the cane plant have shown amazing differences in the types of root systems. The secondary developments from the primary roots are of utmost importance in giving the plant adequate areas of surface contact with the soil particles and the soil solution. Under conditions of deep fertile soils with desirable physical properties, the root systems become well developed to depths of several feet.

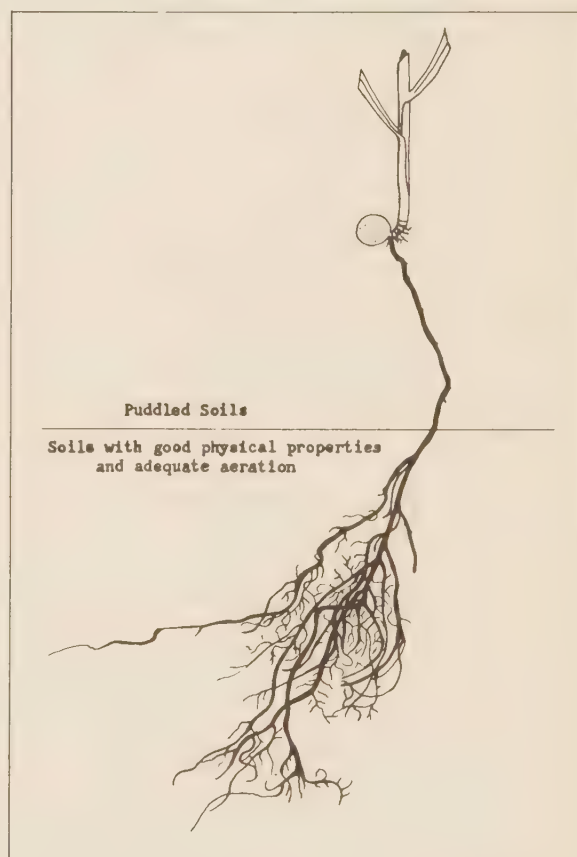
Under puddled soil conditions on the Hilo Coast, root systems were practically devoid of the secondary branching type of roots. Figure 8 is a drawing to scale of a root from a stool of cane at Onomea. The primary root working its way through 10 inches of puddled soil was unable to send out secondary developments. It was only after the root penetrated soils at lower depths with adequate aeration that its secondary roots developed.

Figure 8. Root systems growing in the puddled soils of the Hilo Coast cannot develop secondary growth until the root penetrates into well-aerated soils.

Since exchangeable potassium is extremely low in many soils, heavy potash fertilization is required to insure maximum sugar production.

Several families of soils in the Koloa section of Grove Farm contain unusually large supplies of available phosphorus. The lowest values, in many cases below the critical value, were found in mauka areas. The virgin soils of this region contain very little phosphorus.

Comparisons with virgin soils show that the cultivated soils have suffered appreciable losses of organic matter.



Radioactive materials have been used to determine the efficiency of different types of roots, and the branching type of root illustrated in the lower portion of Figure 8 is many, many times more efficient in moving nutrients into the plant than is that represented by the upper portion.

Root systems grown under conditions of excessive moisture, either from natural causes or from over-irrigation, have only weakly developed secondary roots, which are many times less efficient than roots grown with adequate aeration.

Radioactive studies comparing the old root sys-

tems of the plant crop with the new ones of a ratoon crop show the new roots to be amazingly superior, and indicate that fertilizers for ratoons should be placed as close to the stool as is possible. An old root with its cortex in various stages of decomposition, but with a live stele, remains active, but the rate at which plant food moves is extremely slow and the total quantity moved in is very, very small. Studies with radioactive phosphorus using such an old ratoon root gave no positive count in the stool after one month's time, while positive counts were recorded in the plant with new roots after only 20 minutes.

SOIL IMPROVEMENT—AN OPPORTUNITY FOR MORE SUGAR

Yield results from observation tests harvested to date indicate substantial gains in terms of cane and sugar when organic materials have been added to the soil. Field scale tests at Kekaha have proved the practical significance of soil improvement in the heavier types of soil.

The period of time over which the additions of organic materials will give improved physical properties in the soil is of great economic importance. Tests at Kekaha showed optimum physical characteristics two and a half years after the application of 15 tons of bagasse per acre. Infiltration studies showed 6 acre inches of water took five minutes to seep into the treated plots while four to five hours were required in the check plots. The root systems in the check plots were restricted to the surface 4 or 5 inches, while beautifully developed root systems to depths of 14 to 16 inches were observed in the improved areas. Cane and sugar yields appear to be in about direct proportion to the development of the root system.

The effect of adequate aeration on the develop-

ment of root systems in the heavier types of soil is well illustrated in Figure 9. This picture was taken at Kahuku in the 20-ton per acre bagasse plots after one year's growth. In these same plots the cane is sub-normal, having been starved for nitrogen from the start. Pot studies with the same soil plus treatments of 20 and 100 tons of fresh bagasse per acre have produced satisfactory cane, but only after heavy and repeated applications of N during the early history of the crop. The N requirements of the microorganisms must be met through adequate fertilization during the initial stages of decomposition of the bagasse.

Trash, with its lower carbon to N ratios, has given excellent response in terms of soil improvement and of the appearance of the cane. Grade A tests to determine yield differences are now installed at Lihue and on the Hilo and Hamakua coasts.

Soil improvement to minimize differential fertilization, irrigation, weed control, etc., is becoming plantation practice and a number of plantations are hauling trash and bagasse to the poor spots in their fields at time of plowing.

SPECTROGRAPH PROVING USEFUL TOOL IN FERTILIZATION RESEARCH

Chemical analyses now being made with the aid of the spectrograph on all of the elements known to be essential to the growth of sugar cane, are showing wide differences in composition of both the plants and the soils in which they are grown.

Growth failure areas and problems associated with "leaf freckle" are now under critical review, and un-

usual findings of differences in composition, either as excesses or as deficiencies, are used in skirmish tests to indicate the effective treatments.

It is anticipated that in a relatively short time sufficient data will have accumulated to provide a basis for the diagnosis of nutritional disorders as they occur.



Figure 9. Root system at Kahuku in 20-ton per acre bagasse plots at 12 months of age.

CROP LOGGING EXPANDING ON INDUSTRY-WIDE SCALE

Although harvesting results of two Grade A experiments at Oahu Sugar and Kahuku, comparing crop log procedures with variations of plantation practices, showed no significant differences in yield, periodic examinations of the growing cane are becoming increasingly popular because they serve to point out conditions which may be remedied. The Kahuku test, for instance, brought into focus the low values of K_2O in the sheath at relatively high levels of K_2O fertilization.

Research is in progress to define critical levels of nutrients at different stages of cane development. For

example, during 1951, some 25 Grade A amounts-of-nitrogen experiments were logged for N. Experiments were selected where the differential in N application occurred when the crop was "closed in". By sampling leaf N before the fertilizer differential was applied and checking the treatments against harvest results, it is possible to establish critical leaf N levels for the particular experimental conditions. By grouping the critical N levels according to variety, age of sampling, month of sampling, age of harvest, etc., more accurate predictions of the crop log data can be made. Examples of the data being accumulated are as follows:

Expt. No.	Variety	Age	Month	Age at Harvest	Critical N Level*
Waialua 180 VxAN	37-1933	12	March	26 mos.	1.60
180 VxAN	32-8560	12	March	26 mos.	1.48
180 VxAN	44-3098	12	March	26 mos.	1.40
Waialua 178 AxTN	37-1933	12	April	25 mos.	1.49

* Leaf N per cent which is not adequate to carry the crop through to harvest with maximum sugar yield.

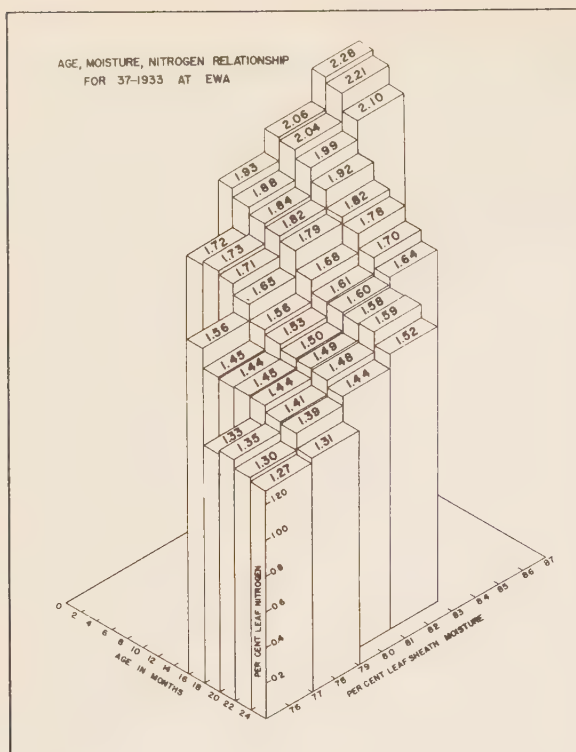


Figure 10. Relationships between N, sheath moisture and age of cane, as shown at Ewa.

to release these data for study insures a more rapid advancement of the industry-wide crop logging program.

The relationships existing between N, sheath moisture and age of cane at Ewa are presented in Figure 10. In the central range of leaf N, from 1.3 to 2.0, mean sheath weights are larger than at extremely high leaf N levels. A direct relationship was shown to exist between leaf N and sheath P_2O_5 at the lower P_2O_5 levels. Leaf N rises with each rise in sheath P_2O_5 up to the .1 per cent P_2O_5 level. There was a definite increase in the leaf N per cent in January and February due to N application, but no effect on the leaf N curve was shown from N fertilization in June and July. Similarly, the Kohala data showed that samples taken in the winter months have higher leaf N percentages than samples taken from the same aged cane in the summer months. At Kohala there exists an N gradient with elevation—lowest leaf N at the lower elevations and highest leaf N at the higher elevations.

A second approach covers a critical review of crop logging as it is practiced at Ewa, Kohala, Waialua and H. C. & S. The willingness of these plantations

Observations such as these, and others that will crystallize from continued study, are certain to rate some form of crop logging as an important tool in the efficient growing of sugar cane in Hawaii.

IRRIGATION RESEARCH POINTS OUT DIFFERENCES IN SOIL'S NEED FOR WATER

By the use of equipment built to define the moisture holding characteristics of soils, curves are plotted from field capacity to wilting point showing the tensions with which the soil particles hold their films of moisture at different degrees of wetness. Some characteristic curves are presented in Figure 11.

Curve No. 1 represents the typical red-colored, light-textured soils of H. C. & S. The low water-holding capacity is indicated by the ease with which water is extracted. The "L" shaped character of the curve shows that practically all of the moisture is available to the plant at low tensions. It is in these types of soil that tensiometers will operate at their optimum efficiency.

Curve No. 2 represents the dark-colored, heavy-textured plastic clays at H. C. & S., and is also char-

acteristic of the heavier soils at Ewa, Kahuku, Kekaha, etc. In this type of soil the water is not equally available at all tensions from field capacity to wilting point. As the soils become drier, the moisture is held with greater and greater force. In this type of soil it is necessary to have recording instruments which can operate satisfactorily at the higher moisture tensions.

Curves 3 and 4 illustrate soils with intermediate moisture-holding properties.

The relationship existing between 15 atmospheres tension and the permanent wilting point was checked by carefully controlled pot studies with sunflowers. Very close agreement between the two values indicates that the pressure membrane technique gives a satisfactory measure of the permanent wilting point of the majority of sugar cane soils in Hawaii.

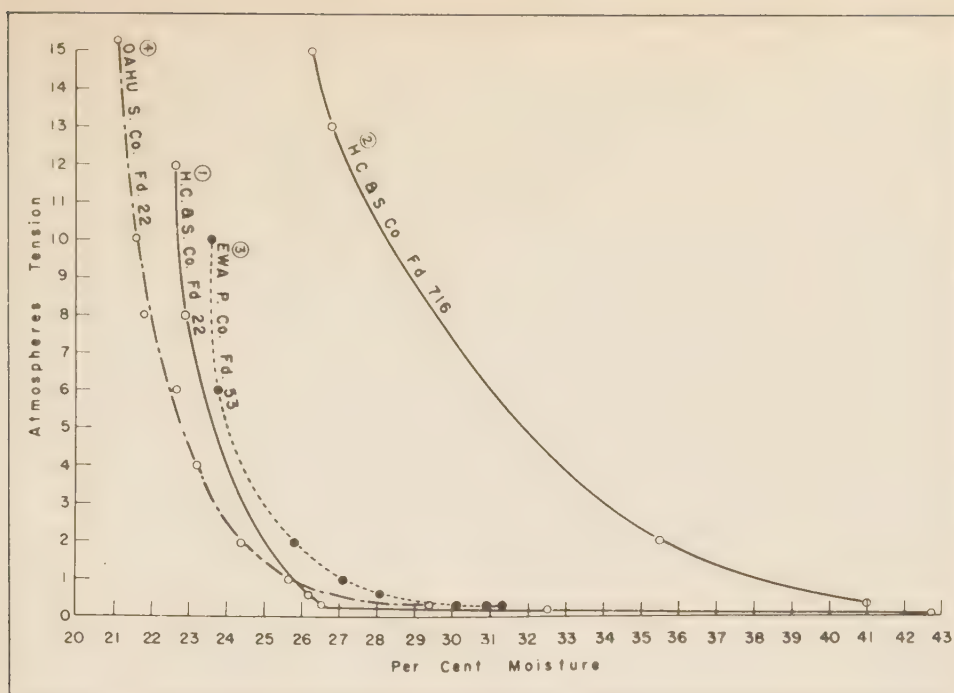


Figure 11. Typical moisture sorption curves of Hawaiian soils.

NYLON BLOCKS SHOWING EXCEPTIONAL PROMISE

Moisture sorption equipment is defining the soil moisture relationships which exist in Hawaiian soils, and efficient irrigation control now hinges on the development of a satisfactory recording instrument for use in the field.

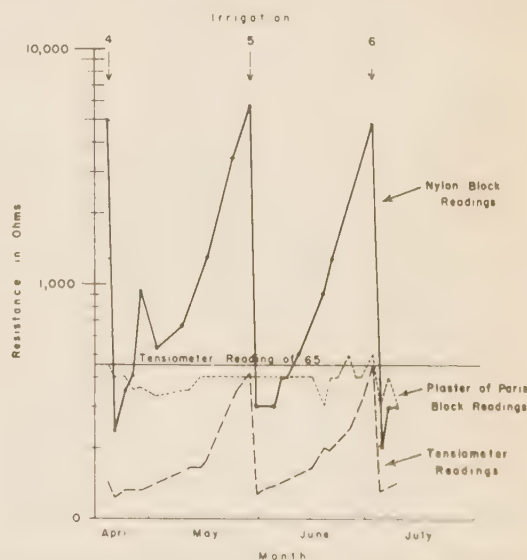
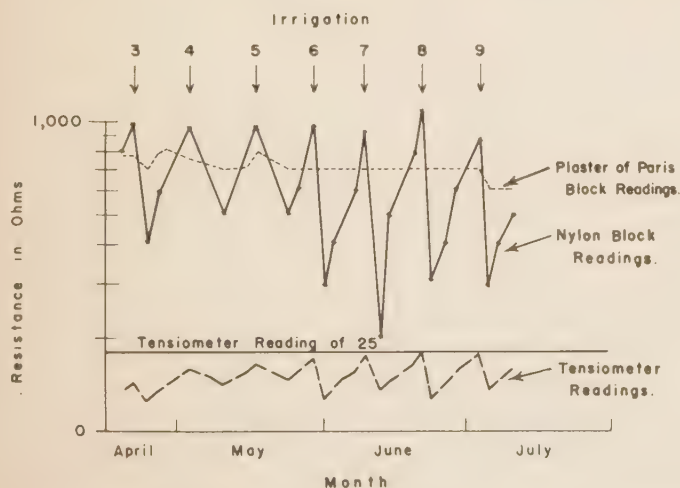
The use of tensiometers is restricted to the lighter textured soils which release moisture at low tensions, but high initial cost and high cost of maintenance are definite disadvantages. While the plaster of Paris blocks are operating satisfactorily at present in a number of different types of soil, their chief disadvantage

is that they are not sensitive in wet soils.

Studies with the nylon blocks at Makiki and recent studies in the field at Oahu Sugar and H. C. & S. have shown the nylon blocks to be exceptionally promising since they are sensitive in both the wet and dry ranges of the soil moisture curve.

The study at both plantations has demonstrated exceptionally good correlations between the nylon blocks and tensiometer readings in relatively wet soils (Figures 12 and 13), and preliminary data show that nylon blocks are equally useful in relatively dry soils.

Figures 12 and 13. Comparisons made of plaster of Paris and nylon blocks in a field at H. C. & S., irrigated at two tensiometer readings. In Figure 12, the field was irrigated at a tensiometer reading of 25, while in Figure 13, the tensiometer reading was 65.



MECHANICAL HARVESTING REDUCING YIELDS ON HILO COAST

Intensive studies by agronomists have correlated poor cane growth with puddled soil conditions which are often brought about by the operation of heavy equipment during wet weather. Studies of the physical

properties of these soils have emphasized the importance of proper pore space distribution and adequate aeration for the development of the cane's root system.

SOILS ENGINEERING DATA USED TO DEFINE HARVESTING OPERATIONS

Penetrometer studies and soil moisture data are now used at H. C. & S. to select fields for harvesting operations with Tournahaulers during periods of wet weather. Alcohol burning is used for quick moisture determinations to define trafficability of soils.

More elaborate soils engineering tests are planned to define the "fluid flow" zone of the compaction curve of each important type of soil, and by proper timing to minimize the damage done by mechanical equipment.

AGE OF HARVEST TESTS CONTRIBUTE USEFUL INFORMATION ON COMMERCIAL VARIETIES

Determination of the optimum age of harvest for a specific variety planted in a certain season should prove a useful guide in scheduling harvesting operations.

The data from Ewa's test presented in Figure 14 illustrates the importance of knowing when to harvest for maximum return. The .74 TSAM at 21 months is an amazing production. The decline in the rate of

sugar production after the high point is passed will undoubtedly lead to timing of operations so that the highest rates of production may be assured.

It is hoped that optimum age of harvest data will be established for all outstanding new varieties as they are more widely adopted, so that as commercial varieties their proper harvesting age can be used to advantage.

Figure 14. Age of harvest test at Ewa indicates clearly the period when harvesting would bring maximum returns.

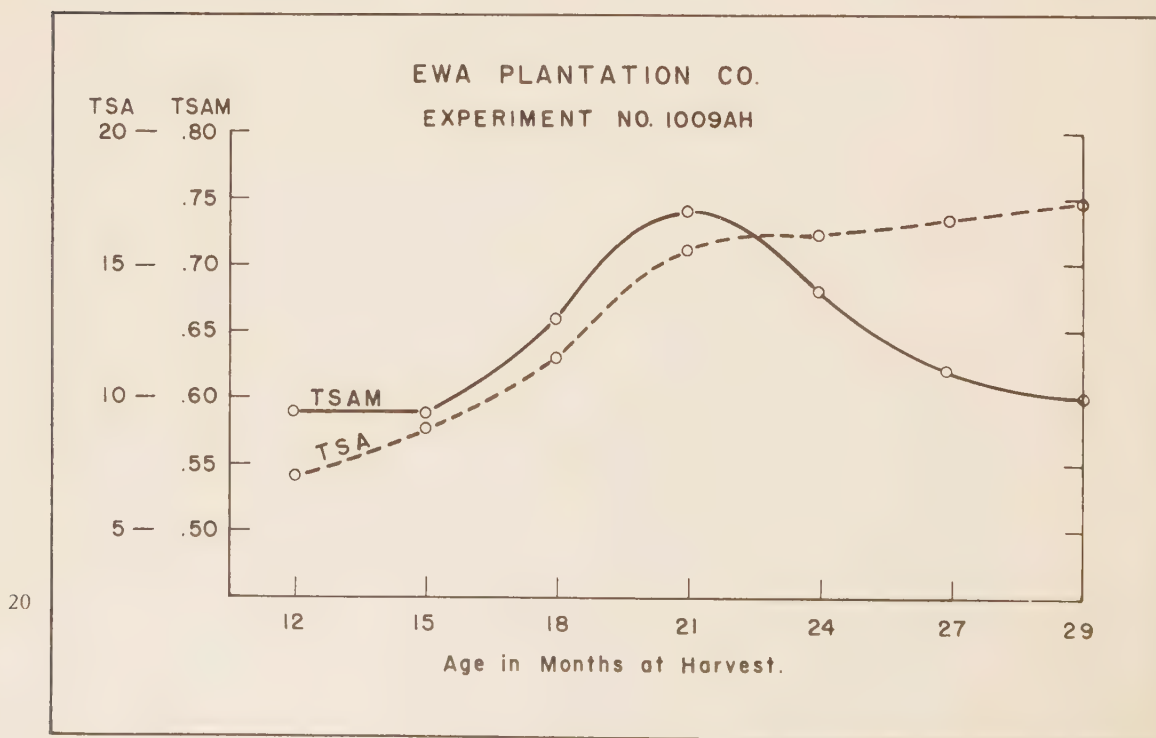




Figure 15. Leaf symptoms of downy mildew on Argus in Nausori, Fiji. Note striping of cane and dead areas of tissue in affected leaves.

DISEASES

CANE DISEASE CONTROL IN AUSTRALIA

At one time cane diseases caused serious losses to the Australian sugar industry, while today such losses are at a minimum. The highly effective disease control program has been brought about by (1) government legislation, which prevents the movement of susceptible varieties into disease-free districts and permits the planting of only the approved, disease-re-

sistant varieties; (2) selecting healthy planting material; (3) roguing diseased plants; and (4) treating planting material with hot water and fungicides.

The pathologists in Australia believe that downy mildew (Figure 15) would constitute a greater threat to the Hawaiian sugar industry than does Fiji disease.

FIJI DISEASE TRIALS IN SAMOA

At the Samoan station, started in 1946, some 380 varieties, mostly Hawaiian grown, have been tested against Fiji disease (Figure 16). The results of the completed varietal resistance tests have been submitted, and the reaction of the present day commercial canes to Fiji disease was published in the Experiment Station Committee Report for 1950.

During the past two years, attention has been centered on the mechanical transmission of Fiji disease. Six methods frequently used for transmitting virus diseases have been tried. In each case, cane juice extracted from leaves and stalks of diseased plants was injected into healthy plants of a susceptible variety. No mechanical transmission of the disease has yet



Figure 16. 37-1933 is shown at the Samoan Substation at the age of 7 months. Note the severe stunting caused by Fiji disease in contrast with the healthy cane.

been accomplished. As far as is known, the disease is transmitted only by the sugar cane leafhopper.

Other phases of research under way, dealing chiefly with the transmission of the disease, are: (1) close plantings of diseased plants with those being tested (rows 18 inches apart); (2) placing cut stalks of diseased cane carrying leafhoppers in contact with healthy growing canes; (3) shaking hoppers from diseased cane onto healthy growing cane; (4) testing varieties for disease resistance where both parents are

highly susceptible to Fiji disease; (5) maintaining a collection of Samoan canes and related plants in a museum area; (6) growing healthy 32-8560 and 37-1933 and diseased Tolo-fua-lau canes in a screen cage and introducing large numbers of leafhoppers of all ages from time to time (this test was started August 1948, and 32-8560 and 37-1933 still remain healthy); and (7) making leafhopper counts at periodic intervals to study the insect population in relation to environment and incidence of disease.

DISEASE TRIALS MOVED TO FIJI

The Experiment Station Committee approved the recommendations of the Quarantine Committee dated May 25, 1951, that officials of the Colonial Sugar Refining Company, Ltd., of Australia, be consulted immediately on the feasibility of a cooperative arrangement with the HSPA to have Hawaiian cane varieties tested in Fiji against downy mildew and Fiji disease.

The proposed plans for testing Hawaiian varieties were prepared by Messrs. P. E. Robinson, J. L. Chalmers of the CSR, and J. P. Martin of the HSPA in

Fiji (August 25 to September 14, 1951) and approved by the two organizations. All Hawaiian varieties sent to Fiji will be grown in quarantine for 12 months and then planted in the disease trials. The plan calls for 100 Hawaiian varieties to be tested the first year, and 25 each year thereafter, the first lot of Hawaiian varieties to be sent to Fiji in October, 1951.

Inasmuch as the above agreement has been reached to proceed with the disease trials in Fiji, the Experiment Station Committee has asked that the Substation in American Samoa be closed by February 1, 1952.

LOSSES FROM DISEASE SMALL IN HAWAII

Losses from the major diseases were at a minimum during the past year and were considered to be the lowest for 25 years or more. No new cane disease was observed. Eye spot was of no significance; a small amount was noted at Olaa on 32-3677. Brown stripe was present to a limited extent in a few areas. Chlorotic streak was causing some losses, particularly in wet and poorly drained localities on Hawaii. Leaf

scald was observed on 28-4291 and Yellow Caledonia, but was causing little damage; both of these canes are being replaced with resistant varieties. Mosaic has not been found on any of the present day commercial varieties. Pythium root rot was not a factor in field culture. Leaf freckle was moderate to severe on certain varieties growing under specific mauka conditions.

LEAF FRECKLE CORRELATED WITH LOW FERTILITY

Results of cooperative studies with plantations, Island Representatives, and the Departments of Pathology and Agronomy show that the presence of leaf freckle is correlated with subnormal soil fertility.

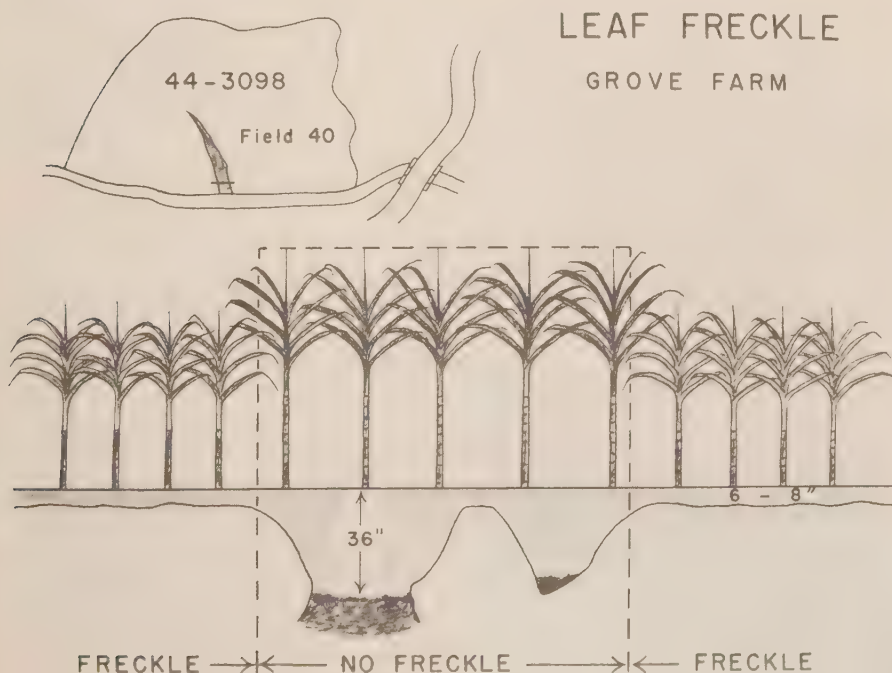
A striking case supporting this viewpoint was observed at Grove Farm where the variety 44-3098 showed no leaf freckle in one narrow strip of the field as against the severe manifestation of the disease in the rest of the field (Figure 17). The soil conditions underlying the "no freckle" and "freckle" areas were studied by making soil borings and digging trenches through the areas. In the "no freckle" area

the soil was dark in color, high in organic matter, and well aerated to a depth of 36 inches. In the "freckle" area, the top soil was from 5 to 8 inches deep with a dark yellowish clay subsoil. The deeper soil had resulted from the filling of an old erosion ditch while the field was being cleared and prepared for planting.

A similar example was studied at Waialua, where 38-2915 growing on very shallow top soil was severely affected with leaf freckle; while in other parts of the field, where the depth of the soil was sufficient to support normal growth, no freckle was found.

Complete chemical analyses of the leaf blade and

Figure 17. The dark strip in the upper field sketch marks the area which showed no leaf freckle, while the rest of the field was moderately to severely affected. The cross section through the "no freckle" area shows a much deeper soil than the rest of the field. The low fertility of the shallow soil can definitely be correlated with the presence of leaf freckle.



sheath, top soil and subsoil, from these areas are being determined. Attempts to improve soil fertility in the freckle areas, based on these analyses, will be made.

Isolations for a possible pathogen from freckled leaves have been carried out. Several isolates tested on normal 44-3098 grown at Makiki have failed to produce leaf freckle. Even though leaf freckle is caused by a specific organism, the severity of the disease is governed by the effect on the plant of environment: temperature, moisture, nutrition, light,

soil aeration. Of the environmental factors, the data at hand indicate that improper nutrition, or low soil fertility which weakens or retards the growth of the plant, has the greatest effect on weakening the resistance of the plant to the disease.

Leaf freckle and brown stripe can attack only weakened plants so that their presence may be used as an "indicator" of subnormal soil fertility. One authority states, "No disease can result unless the environment favors its development."

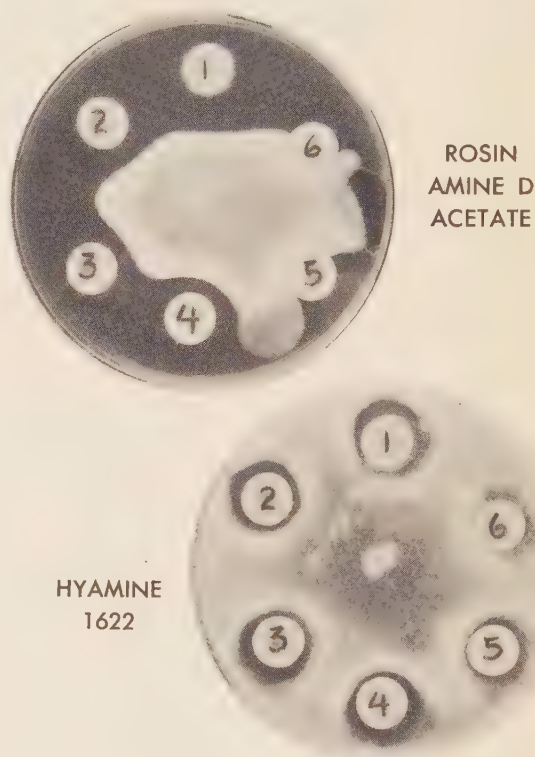
PYTHIUM ROOT ROT CONTROLLED IN SEEDLING FLATS

Pythium root rot was satisfactorily controlled in flats of cane seedlings by treatment with Phygon.

Thirty-two fungicides were tested against *Pythium* sp. in the laboratory (Figure 18). Fungicides which gave control of the organism in the laboratory will be tested further when cane seedlings are being grown in flats.

In an attempt to control *Pythium* root rot of seedlings, *Actinomyces*, which produced antibiotic substances effective against *Pythium* on agar plates in laboratory tests, were used to inoculate soils in which cane seedlings were grown. Although satisfactory control was not obtained in these preliminary tests, the project is being continued.

Figure 18. *Pythium* root rot organisms were grown on potato-dextrose agar in petri plates where different concentrations of fungicides were added to paper discs. One drop of a 2 per cent solution of the fungicide was added to No. 1 disc, and each higher number received a drop of fungicide one-half the strength of the one preceding it. The petri plate in which Rosin amine D acetate was tested showed it to be effective against *Pythium* at 2, 1, $\frac{1}{2}$, and $\frac{1}{4}$ per cent but not at $\frac{1}{8}$ and $\frac{1}{16}$ per cent. Hyamine 1622 was less effective for the control of *Pythium*.



HERBICIDES NOT HARMFUL TO SOIL ORGANISMS

The effects of 2,4-D, CADE, and CADE + 2,4-D, on nitrate nitrogen formation and soil organisms in Kansas soils were studied by Hideo Koike at Kansas State College, where he received his Master of Science degree in soil microbiology in January, 1951. The results of these investigations showed that the herbi-

cides when applied at the rates now used in Hawaii caused little or no harmful changes in Kansas soils, and the same should be true with Hawaiian soils. When the herbicides were applied at rates much higher than normal field application, the accumulation of nitrate nitrogen was definitely retarded.



Figure 19. A comparison was made of the germination and subsequent growth of "good seed" and "poor seed" when (1) inoculated with the pineapple disease organism, *Ceratostomella paradoxa*, (2) given no treatment, and (3) treated with phenyl mercuric acetate (PMA) soon after cutting. Good germination was obtained from all cuttings of "good seed" and for the "poor seed" treated with PMA. "Poor seed" not treated with PMA germinated poorly. Growth of shoots from "good seed" was better than from "poor seed." It pays to plant "good seed."

GERMINATION STUDIES WITH "GOOD" AND "POOR" SEED

A small test was installed at the Pathology Plot to observe the effect on germination of "good seed" and "poor seed" when treated with and without phenyl mercuric acetate (PMA) immediately after cutting, and when inoculated with the pineapple disease organism, *Ceratostomella paradoxa*, 0, 1, 2, and 3 days before planting. Cuttings designated as "good seed" were from actively growing stalks of the variety 32-8560, from which four three-eye cuttings were taken. "Poor seed" was from stalks which had tasselled and lalaed, seven to eight cuttings being taken from each stalk. Cuttings were planted in March when conditions were favorable for germination. A high percentage of germination was obtained from all cuttings treated with PMA immediately after cutting, although faster germination and growth was observed from the "good seed." "Good seed" planted two and three days after inoculation with *C. paradoxa* did not ger-

minate as well or grow as rapidly as cuttings inoculated one day earlier or on the day of planting. The pineapple disease did not appreciably affect the germination of "good seed" when conditions were favorable for germination. However, a very low percentage of germination was obtained from all cuttings of "poor seed" not treated with PMA, whether or not they were inoculated with *C. paradoxa* (Figure 19).

Several plantations have installed large tanks for treating cane cuttings with hot water, PMA, and hot phenyl mercuric acetate (HPMA) (Figure 20). Other plantations spray the freshly cut ends of the cuttings with Ceresan or PMA. Experimental field studies have shown that these treatments have increased germination and have protected the cuttings against rotting by the pineapple disease organism, especially during the winter months when environmental conditions are less favorable for growth.

Figure 20. The hot-water unit used at Hilo Sugar Company for treating cane cuttings for chlorotic streak control and seed stimulation is similar to the portable unit used for PMA treatments given in the field.



CHECKING ON STRENGTH OF PMA SOLUTIONS

A procedure was developed by the Departments of Physiology and Biochemistry, Chemistry, and Pathology to determine the strength of PMA solutions.

The use of chemicals (inhibitors) in the PMA solution to prevent the reduction of the mercury when used in metal tanks was found to be uneconom-

ical. It is suggested that such metals as iron and zinc which come into contact with PMA solutions should be coated with red lead or some other suitable paint to prevent oxidation of the metal. Stainless steel and copper were less affected by PMA solutions than other metals tested in laboratory studies.

Handbook of Approved Field Designs

3 x 2 Factorial Designs

6 x 6 Latin Square; 6 Treatments; 36 plots.

Factor *1: Treatments A, B, C;

Factor *2: Treatments D, E.

Combined treatments: 6

No 12a:

BE	CE	AD	CD	BD	AE
AE	CD	BD	CE	AD	BE
BD	AD	BE	AE	CD	CE
CD	AE	CE	BD	BE	AD
AD	BD	AE	BE	CE	CD
CE	BE	CD	AD	AE	BD

Analysis:

Source	d. f.
Rows	5
Columns	5
(Treatments)	(5)
Factor *1 (A, B, C)	2
Factor *2 (D, E)	1
Interaction	2
Error	20
Total	35

EXPERIMENTAL STATISTICS

THE DESIGN OF FIELD EXPERIMENTS

The Experiment Station Committee approved a plan to have all cooperative Grade A tests designed for analysis of variance. This is an important step towards the planned grouping of experimental material

so essential in reducing experimental errors. A 40-page mimeographed "Handbook of Approved Designs for Grade A Experiments with Sugar Cane" has been prepared and distributed to plantation agriculturists.

SIZE AND SHAPE OF PLOTS BEING CRITICALLY EXAMINED

Theoretically, small plots should show less plot-to-plot variability than large plots since they can be placed closer together where greater similarity of soil and growth conditions can be expected between them. Actually, because of plant-to-plant variability, the very small plot is unsatisfactory because its population of plants is an inadequate sample. Hence, it has been difficult to find an optimum size of plot for sugar cane tests, and so it has become common practice to use a size that is most convenient for harvesting.

Blank test yields from old as well as new installations were studied to find out how changes in the size

and shape of unit plots within each test area would affect their variability. Briefly stated, it was found that variability was decreased as the plot size was increased. Doubling the size of plot reduced the coefficient of variation (C.V.) from 11.8 per cent to either 9.4 or 10.1 per cent depending on whether the plots were increased in length or in width respectively.

Changes in the shape of plots with equivalent areas show that especially on unirrigated areas, longer rows were more effective than more rows in reducing the C.V. On some of the irrigated layouts, the average

Rows →	Average C. V. :	<u>All (23)</u>	<u>Unirrigated (6)</u>	<u>Irrigated (17)</u>
Single Unit		11.8	12.6	11.6
Doubled: longer rows		9.4	9.2	9.4
Doubled: more rows		10.1	11.8	9.5

Figure 21. Effect on coefficient of variation (C.V.) from changes in the size and shapes of plots.

C.V.'s for the longer plots were not significantly below those for the wider plots. (See Figure 21.) However, in seven out of nine good comparisons from "herring-bone" irrigation layouts at Waialua, the shorter, wider plots were less variable (C.V. at 7.7 per cent) than the longer, narrower plots (C.V. at 11.0 per cent).

An acceptable specific size for so-called "small" plots has not yet been recommended. Plots as small as .05 acre have been quite satisfactory for many years, but very little information has been available for study of plot sizes smaller than this. A total of 139

30x30 variety tests showed an average C.V. of 11.4 per cent for the check plots therein; this would, of course, be reduced by proper designs. Twenty well-replicated tests using plots between .02 and .03 acre have been harvested during the past few years. Fourteen of these, harvested by experienced hand cutters from Waipio, have had a C.V. of 9.2 per cent; six others harvested by less experienced hand cutters have had an average C.V. of 12.8 per cent. Apparently it will be worthwhile to train and use a small gang of men to hand-harvest tests which are installed on small plots.

CAN HARVESTING FIELD TESTS BE SIMPLIFIED?

A study is being made on the possible advantages of harvesting test plots in such a way that yields would be secured by taking all cane lying within the plot boundaries at harvest rather than attempting to pull and separate stalks in order to get all those which have their origin in the plot. If such a harvesting

procedure can be shown to be without bias on yields and without serious effect on plot-to-plot variability, there are obvious advantages in the proposed method.

Although the work has not as yet progressed sufficiently to evaluate the results, they are not discouraging.

JUICE SAMPLING PROBLEMS

From 4000 Brix readings made in Wailuku Field 97 on juices taken with a punch sampler from several internodes, the extent of variability between stations or locations in the field, between stalks within stations, and between five designated internodes of stalks was studied. Highly significant variation was found between stations, but the stalk-to-stalk variation contributed the greater part of these differences.

For instance, the stalk-to-stalk variance for Brix was 3.26 as compared with a true station-to-station variance (i.e., station variance without stalk sampling error) of 0.75.

Variation between internodes was found to be less in the physiologically older regions of the stalk (Figure 22). Since the best sample is one that is both sensitive to external influences and that shows

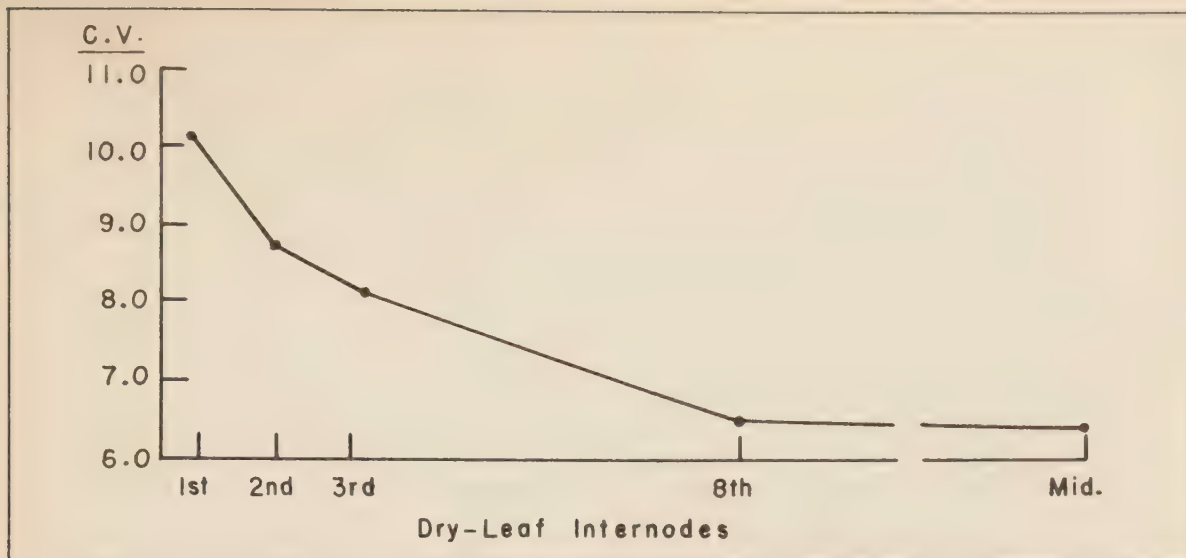


Figure 22. Extent of variability (C.V.) in Brix between internodes of cane.

little variation due to uncontrollable conditions, it appears that the region of the second to third dry-leaf internode would be a more satisfactory point for Brix sampling from the immature portion of the stalk than the commonly used first dry-leaf internode, and that any point between the eighth dry-leaf internode and middle of the stalk would be satisfactory for the dry-leaf section.

These same data show that there was less variability in juice between specifically numbered internodes

(eleventh and/or twelfth), numbered downward from the spindle, than between internodes identified as first dry-leaf, second dry-leaf, etc. Since Brix changes are rather sharp between adjacent internodes in the top part of the stalk, and since any uncertainty as to the identity of internodes, if called first-leaf, second-leaf, etc., would cause a misleading variability in the juices, it was found that results of greater reliability could be obtained when the internodes were designated by number, starting at the spindle.

SIZE OF SAMPLE FOR GOOD JUICE ANALYSES

Comparisons of analyses taken from juices extracted by either small or Cuban A mills with those taken from standard mill crushers have not always given a satisfactory correlation for the prediction of one from the other. During the past year, six studies have been made in which this correlation has been found to be .57, .60, .71, .77, .81 and .95. It is believed that the problems involved in cane sampling are chiefly responsible for the low correlations.

Previous studies of cane sampling have generally led to the conclusion that the extent of variation in juices in the crop to be harvested is quite unpredictable, and so it has been impossible to decide upon a specific optimum size of cane sample for juice analysis *before* harvesting started. Recent studies have not improved this situation very much.

Two studies were made on data from Kekaha where cane samples for juice analyses consisted of three approximately 85-pound bundles taken at random from each plot; this was about 1½ to 2 per cent

of the total cane on the plot. The experimental error for Y%C in these two tests, therefore, included both the plot-to-plot and the sample-to-sample variations. When a breakdown of the data showed the true variances for plots as well as for samples, it became apparent that the variation between samples had contributed most of the experimental error between plots, and that if the experimental error were to be reduced, more samples per plot would have to be secured before increasing the number of plots.

For instance, in one experiment the standard deviation or sample-to-sample variation of .95 was five times that of the plot-to-plot variation of 1.19. There should be 25 samples to bring this sample variance in line with the true variance for plots.

In another experiment, the standard deviation for samples was a little over three times that for plots; this would call for 11 or 12 85-pound bundle samples of cane per plot in order to reduce the sampling error to an equivalent with the individual plot error.



FACTORY

PRESSURE FILTRATION MAY SOLVE RECIRCULATION PROBLEM

The problem of eliminating peak recirculating loads at the clarification station is of major interest to most factories.

Last year preliminary study was made of the clarification of Oliver filtrate by means of a high speed centrifugal. While a redesigned machine for this purpose is being developed by the manufacturer, work this year was directed toward a study of pressure filtration.

Filtration tests were conducted at Waialua on pilot models of Niagara and Sweetland type filters (Figure 23). Results indicate that the use of some

type of pressure filter is a practical way of relieving the load on the clarification station. However, since the cost of operation is such that continuous use of the filter is probably not economical, the equipment should be considered to be of a standby nature.

The estimated cost of filter operation would vary from 13 cents to 39 cents per ton of 96° sugar produced during the crop. This added processing cost can be justified by those factories whose high over-all plantation operating costs are due to slow grinding rates caused by clarification stations which are overloaded at many times during the year.

FROTH FLOTATION METHOD REMOVES LIGHT SUSPENDED SOLIDS FROM OLIVER FILTRATE

Continuing the study of various methods for improving the quality of Oliver filtrate to eliminate recirculation, tests were made on a froth flotation procedure using equipment in the Hawaiian Pineapple Company laboratory. This method involves beating up the filtrate with air, either with or without a flotation agent. The resulting froth is mechanically removed.

The results showed that a considerable quantity of suspended matter can be removed by this method. However, since the material removed is the lighter weight matter, and since the heavy muds remain, the method has possible application in treating juice from the wash cycle but not from the pick-up cycle. A major problem would be froth disposal.

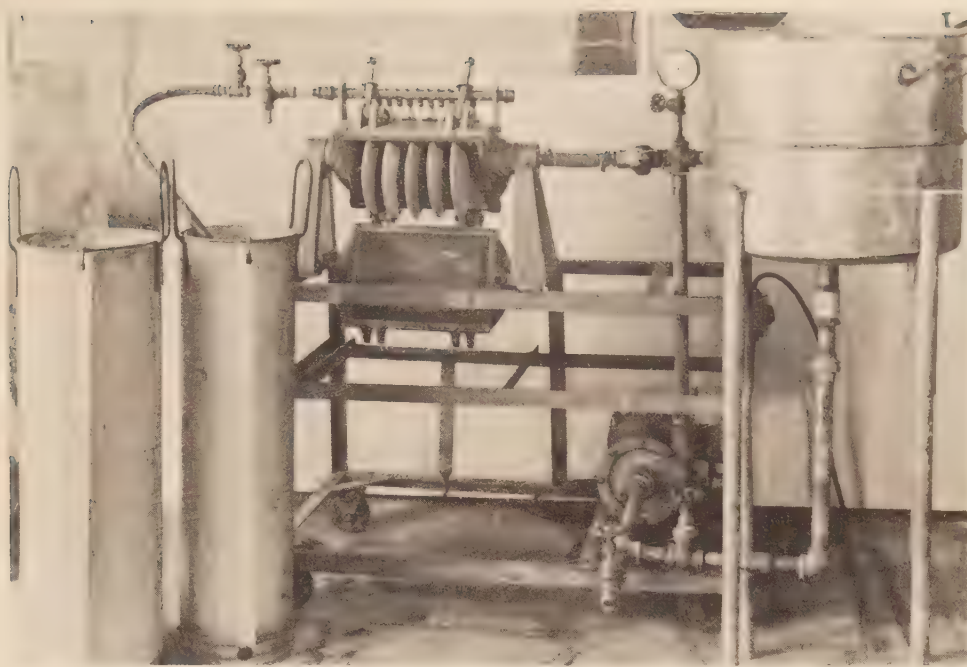


Figure 23. Sweetland Test Filter.

CLARIFICATION EFFECTIVELY REMOVES INSOLUBLE SALTS IN LOW-GRADE SUGARS

Investigation of the causes for salt crystal formation in low-grade sugar and of methods for alleviating the trouble was continued. H. C. & S. set up a program to correlate the phenomenon with field, irrigation water, drying-off and varietal factors. Periodic analyses of samples of juice from field cane are being made. The Experiment Station is analyzing juices from fields as they are harvested at Ewa.

Thus far the results confirm the following:

1. The phenomenon is associated with makai fields.
2. Fields irrigated with pump water are troublesome, whereas those irrigated with mountain water are not.
3. Juices from the troublesome fields are higher in ash content.
4. There is a definite varietal difference. Variety 38-2915 shows considerably lower ash content than 32-8560 or 37-1933.
5. Aconitic acid content variation is not significant.

It is thus apparent that high ash is responsible for the precipitating out of the relatively insoluble salts by a salting-out effect. This effect can become so great that relatively soluble salts begin to crystallize as in the case of H. C. & S. where crystals of potassium chloride have been found in the low-grade sugar.

Aside from changing field practice to obtain lower ash juices, the only effective means of solving the problem in the extreme cases, as far as potassium salts is concerned, is by ion exchange. This is an expensive procedure. Laboratory work has shown, however, that the other insoluble salts can be removed by a simple procedure of dissolving the low-grade sugar and, following a minimum liming, of allowing it to settle for a short period of time at 55 refractometer solids. The clear liquor can then be drawn off and the settlings returned to the Oliver filter. This method is much cheaper than filtration or centrifugal methods.

Sulfitation did not inhibit formation of salts in H. C. & S. syrup and molasses, but did decrease the viscosity.

RADIOACTIVE TRACER TECHNIQUE USED IN CLARIFICATION STUDIES

A basic study of the role of phosphates in juice clarification reactions is being made. The radioactive tracer technique using radioactive phosphorus has been initiated as a cooperative project between the Departments of Sugar Technology and Physiology and Biochemistry. The program is designed to determine the difference in behavior between phosphate present in the plant and inorganic phosphate introduced into the juice, and the fate of the phosphate in each case during the clarification reaction. The

effect of souring of the cane and of introduced soils will also be determined.

For the purposes of the study, cane stalks are being fed radioactive phosphorus so that it becomes a constituent of the juice. Other clarification studies are being made in which radioactive phosphates are added to the juice in clarification.

Preliminary results show that 95 per cent of the added radioactive phosphate is precipitated out by liming to a pH of 7.7, and 98 per cent to a pH of 8.4.

Phosphate Fixation in Juices by Soils

Mill juices with large quantities of soil are often difficult to clarify. Where the original juice is low in phosphate, this may be due to fixation by the soil of a high percentage of the phosphate.

Laboratory work has shown that the fixation varies widely with the type of soil, original phosphate con-

tent of the juice, and condition of the juice. However, moderate amounts of soil will fix 50-60 mg. of phosphate per liter of juice. Of considerable importance is the finding that juice from damaged cane left standing long enough to develop appreciable acidity is more susceptible to fixation than fresh juice.

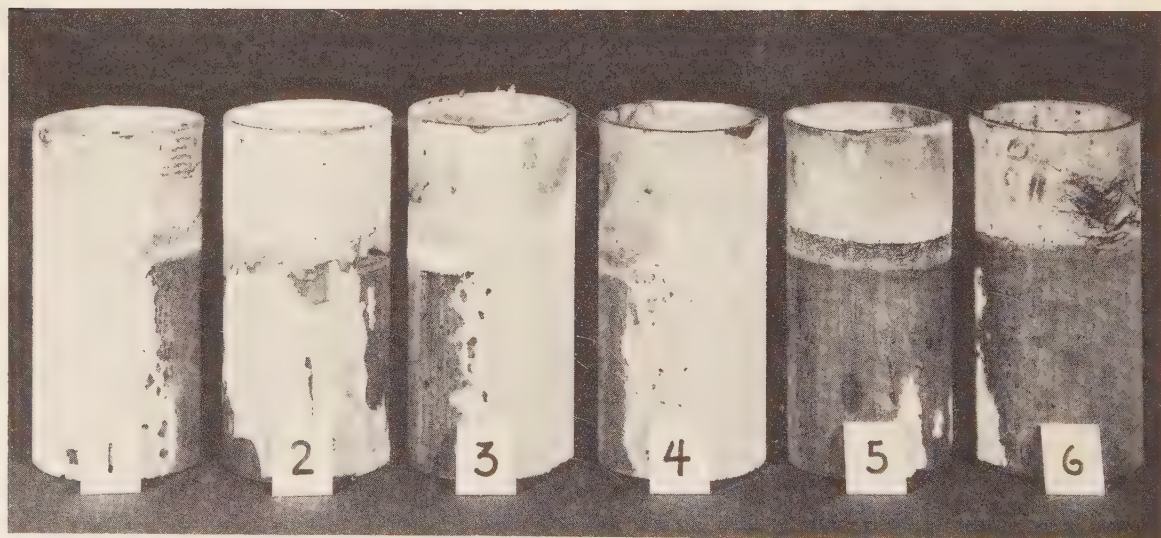
Clarification with Co-Precipitates of Aluminum and Magnesium

From a theoretical standpoint, gels formed by co-precipitation of aluminum and magnesium hydroxides should be effective clarification agents. Several gels of this nature of varying ratio of aluminum to magnesium have been made and tried as clarification agents. So far none of these has proved particularly

effective and none changes the negative charge of the suspended particles in mixed juice.

The chief problem involved in the preparation of these co-precipitates is obtaining an ion-free material. It is hoped that improved techniques will lead to an effective material.

Figure 24. Evaporator scale removal by sulfamic acid. No. 1 was treated with 5 per cent sulfamic acid; No. 2, with 5 per cent sulfamic acid plus Oronite; No. 3, with 5 per cent sulfamic acid plus molasses; No. 4, with 5 per cent sulfamic acid plus Oronite and molasses; No. 5, with one per cent HCl plus molasses; and No. 6 with one per cent HCl plus molasses and Oronite.



SULFAMIC ACID USEFUL AS EVAPORATOR SCALE REMOVER

Laboratory tests of scale deposits on evaporator tubes show that sulfamic acid in the presence of a wetting agent is effective in loosening the scale (Figure 24). Although this material is approximately twice as expensive as muriatic acid, it can be used in concentrations of about half that of muriatic, so

that the costs of application are similar.

Sulfamic acid has the advantage of being considerably less corrosive to cast iron than muriatic acid. The new material likewise has the advantage of being a solid, easy to handle, and with no glass-carboy-return problem.

ANALYTICAL STUDY OF MOLASSES EXHAUSTIBILITY EXTENDED

The comprehensive analytical study of molasses exhaustibility, conducted in conjunction with regular boiling down tests, has been extended to 1950 factory composite molasses samples. This program should be complete late in 1952 when all of the 1951 factory samples have been analyzed. It is hoped that by that time, sufficient information will be available so

that molasses exhaustibility can be calculated from analysis figures rather than by the lengthy procedure of a boiling down test. Thus expected purity figures for each factory could be brought to a more up-to-date basis than the present method allows. (Figure 25.)

During this year 27 samples of molasses have been studied under this program.

Figure 25. Apparatus for measuring the viscosity of molasses.

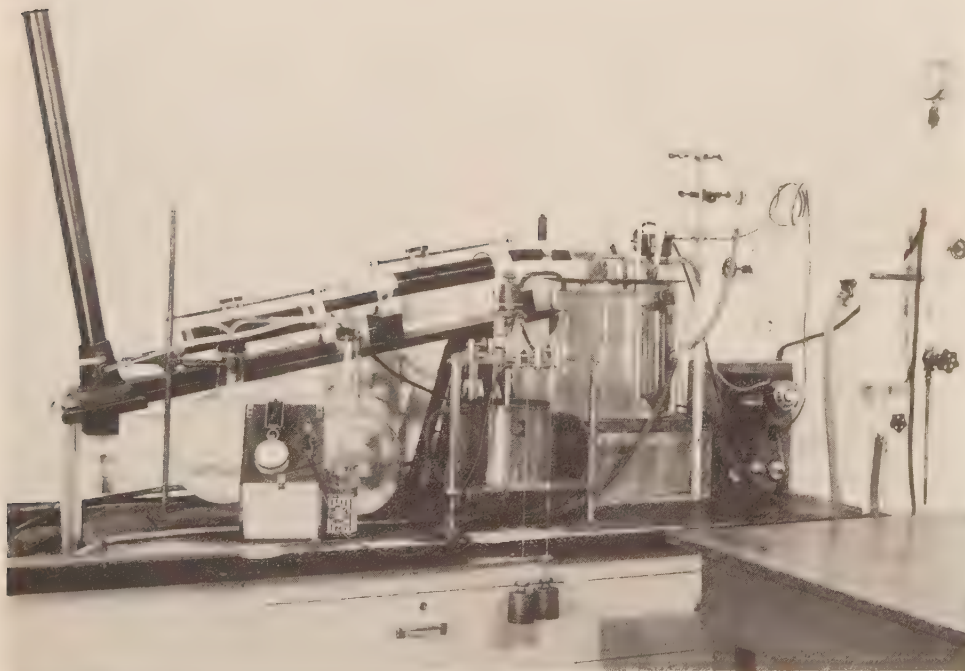




Figure 26. The sugar cane leafroller moth's normal wing-spread is as long as the line inside the brackets. (—————)

INSECTS

There has been little, if any, change in the status of cane insects during the year according to the Department of Entomology. Parasitic control of all of the major pests has remained highly satisfactory, and no new foreign pests have appeared. Minor sugar cane insects, such as the sugar cane leafhopper *Perkinsiella saccharicida* Kirk., the Chinese grasshopper *Oxya chinensis* (Thun.), the beetle borer *Rhabdoscelus*

obscurus (Boisd.), and the mole cricket *Gryllotalpa africana* Beauvois, have been comparatively scarce throughout the year. It is worthy of mention that some of these were once of major importance. There have been some moderate outbreaks of the cane aphid *Aphis sacchari* Zehnt. during hot, dry periods in the summer, but natural enemies have greatly suppressed them.

THE ARGENTINE ANT MARCHES ON

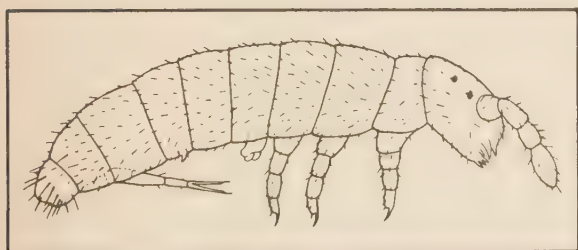
The Argentine ant continues to spread in the Territory. It has been found at the Waimea Ranch Hotel on the island of Hawaii, at Makawao on Maui, and during January, entomologists found it occupying extensive areas in 12 cane fields in the Helemano and Opaepala sections of Waialua Agricultural Company, as well as in some pineapple lands above the plantation. However, it has had very little effect in building up mealybug and aphid populations in the cane fields,

as was at first feared. The parasites of these latter pests continue to operate effectively in spite of the ants. It has been nearly two years since the ant was first observed in cane lands of Oahu Sugar Company and Ewa Plantation. A survey of these areas during June, 1951, showed a positive scarcity of mealybugs in many areas where the ant was very abundant. It is believed that this ant will not be of economic importance in the cane fields.

SUGAR CANE LEAFROLLER A CHRONIC OCCURRENCE IN HAWAII

The cane leafroller *Omiodes accepta* Butl., though one of the minor sugar cane pests, occurs chronically in elevated cane fields of Kau, Hamakua, and Kohala, on the island of Hawaii. Entomologists still consider it a native Hawaiian moth, the normal food of its caterpillars being certain grasses in the uplands. With the expansion of plantation fields into lands 1000 feet or more above sea level, this moth has invaded some of these elevated fields. It has been found particularly common in the varieties 28-4291 and 38-2915, is occasionally seen in the lowlands on Oahu, and is moderately controlled by several parasites. There is still some question respecting its identity and origin. The moth and typical damage to cane by the caterpillars are shown in Figures 26 and 27.

Figure 27. Typical injury to sugar cane by the sugar cane leafroller.



ROOT PITTING BY SOIL ORGANISMS ON HILO COAST

The relation of root-pitting organisms in the soil to retarded growth of sugar cane has been under investigation by the Entomology Department. Minute insects (mainly springtails of the genus *Isotomodes*) are normal inhabitants of all Hawaiian cane soils, and it is estimated that they sometimes occupy the soil at a rate of about 100 millions per acre. One of these little insects is shown in Figure 28. They prefer feeding on humus material normally derived from root remnants of preceding crops, from the rotted cortex which is normal on cane roots after a certain age, or from decomposed trash; but when the supply of humus is not sufficient to support them, they attack



Figure 28. Root-pitting insect *Isotomodes* sp. and the pits in the sugar cane roots made by it. The insect's normal length: (—). The illustration of the root damage is very much enlarged.

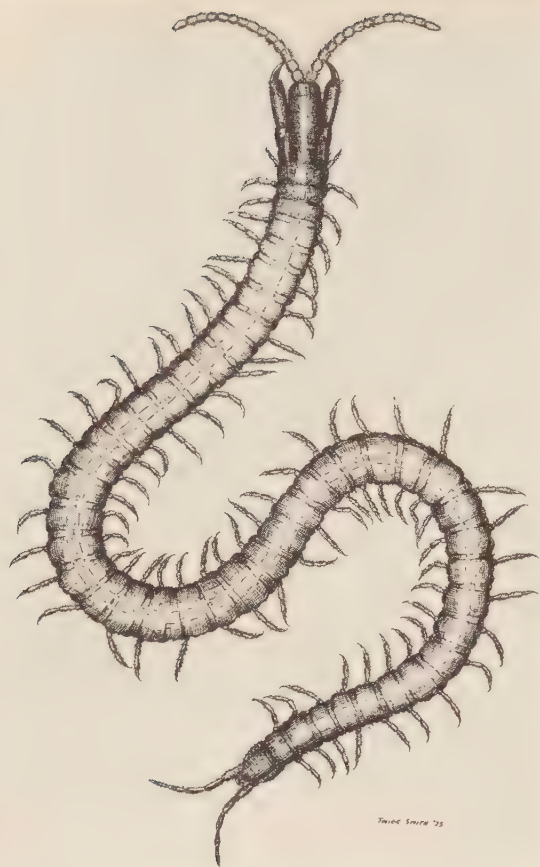


Figure 29. The root-pitting centipede, whose normal length is: (-----). The illustration of the pit made by it in the cane root is greatly enlarged.

the cortex of fleshy cane roots, producing small, circular pits, as shown in Figure 28. When such pits are made at the tip of the growing root, as often happens, the growing point is killed, elongation of the main root is stopped, and secondary roots are produced. When humus material is lacking, such feeding is often very heavy, and results in a short, stubby root system inadequate for normal plant growth. However, in the presence of ample humus, or wherever root production is rapid and abundant, the ratio of pits to unit root length is negligible. For practical purposes, the effects of root pitting can be entirely avoided by ensuring rapid, abundant root growth. It does not matter how this result is obtained: whether by improved fertilization, better soil aeration, change of variety, time of planting, addition of organic matter, or by any other of the practices which come under the heading of good agriculture.

Among the other organisms that cause pitting in cane roots is a small, soil inhabiting centipede *Mecistocephalus maxillaris* (Gervais), shown in Figure 29. The typical feeding pit made by it in a tender cane root is also shown. This centipede is far less abundant than the *Isotomodes*.

SUGAR CANE INSECTS OF THE WORLD

At the Sixth Congress of the International Society of Sugar Cane Technologists held in New Orleans in 1939, the section on entomology recommended that a bibliography of the sugar cane insects of the world be prepared and published. Funds for publishing this book were authorized at the Seventh Congress held in Australia in September, 1950. The book has finally been published, and contains 113 pages of pertinent references to publications dealing with 1283 different insect pests of cane, or their natural enemies, in all parts of the world where cane is grown. It forms a permanent and invaluable handy reference book for entomologists concerned with the control of sugar cane insects.



Figure 31. H. C. & S. cutter-windrower in operation in 112 ton cane.

MECHANIZATION

SIDE-MOUNTED CUTTER-WINDROWER (DUNCAN CUTTER)

The development of the side-mounted cutter-windrower has continued by the Department of Agricultural Engineering in cooperation with plantations, and several changes in design first tested for irrigated cane have been used in a machine for use in unirrigated fields. One change improved the transfer from the pickup tines to the conveyor chains. Another important innovation was the addition of rolls for the removal of soil and loose fines in the

elevating conveyor deck. In order to simplify design and reduce maintenance, further changes are being tested on an unirrigated machine. (Figure 30.)

H. C. & S. has a machine for irrigated cane in operation which is a result of improvements made on the experimental machine. Some of the limitations such as adequate auxiliary power, conveyor width, and power delivered to the ground knife have been improved. (Figure 31.)

DIRECT MOUNTED CUTTER-WINDROWER FOR UNIRRIGATED CANE

The direct mounted cutter-windrower for unirrigated cane is a one-line, two-way machine. The cutting-pickup-elevating conveyor is located directly over the 60-inch gauge prime mover. Since the ground cutting knife is located in the center of the conveyor and there is a side trimming knife on each side, the machine can be turned at the end of a line to cut

back on the next line. The principles used for cutting, picking up, and conveying the cane are based on the side-mounted machines in use. (Figure 32.)

Each end of the cross-conveyor, which picks up the cut cane, extends 2½ feet beyond the width of the elevating conveyor. The conveyor, powered by the prime mover, can be operated in both directions.

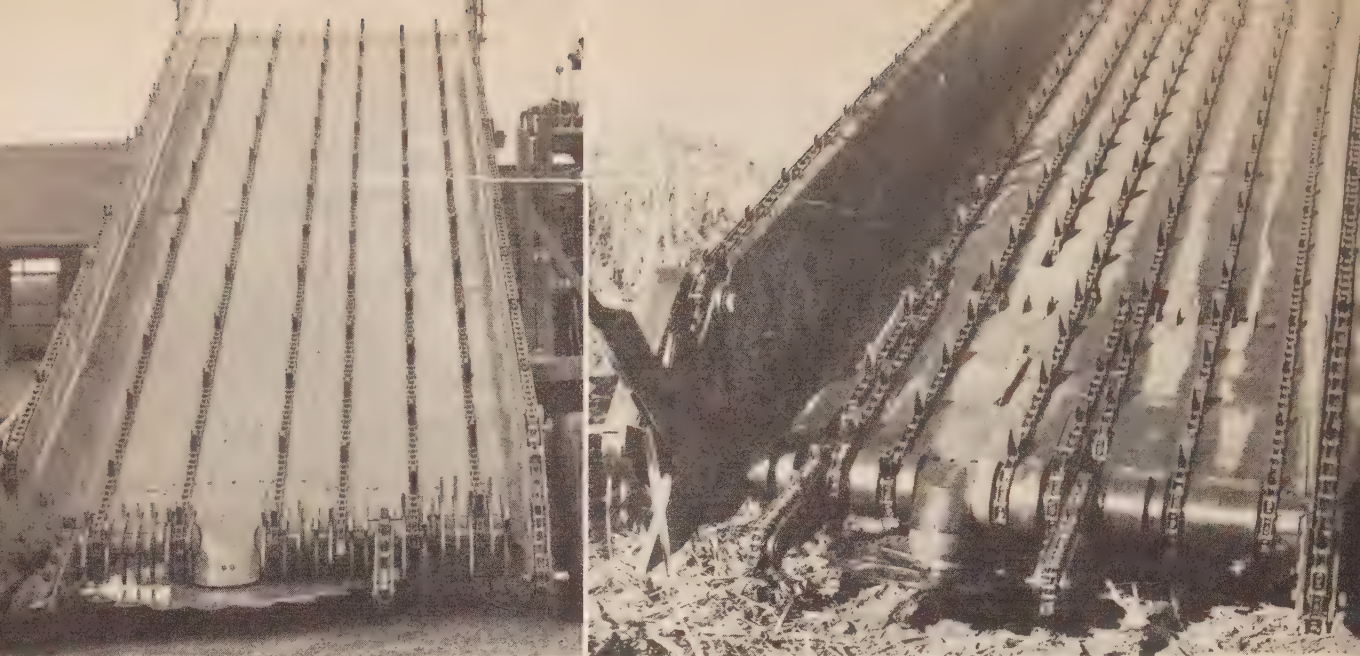


Figure 30. Some of the changes are apparent in this comparison of the old and the new. The picture at the right shows the experimental conveyor assembly.

Two small Diesel engines are used for auxiliary power; one drives the ground cutting knife, and the other drives the remainder of the elevating conveyor.

The completed machine weighed $18\frac{1}{4}$ tons with a calculated ground pressure of 10.3 pounds per square inch. The field operation to date has demonstrated certain definite advantages as compared to the side-mounted arrangement, such as, for instance,

being able to open up the field or new block.

Experimental attachments are planned for this machine with the purpose of leaving more tops and leaf trash on the ground surface, and of reducing maximum stalk lengths. Other possibilities will be explored to determine how such a machine can be improved to contribute most to the harvesting problems with unirrigated cane.

Figure 32. Direct mounted cutter in operation at Hilo Sugar Company.





Figure 33. Experimental suction drum being used to separate field cane from loose leaf trash, using batches cut in pre-determined stalk lengths. A run of 2-foot maximum length is shown.

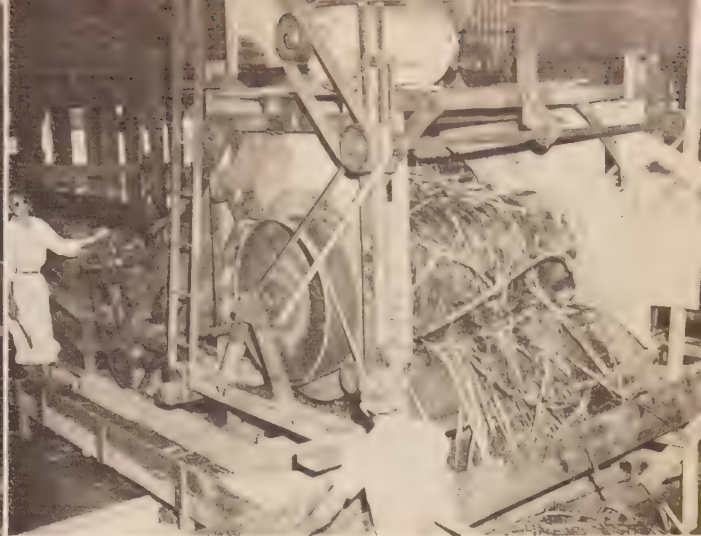


Figure 34. Experimental suction drum operating as a cane salvager at Kohala cane cleaning plant. The cane is returned to the mill cane carrier, while the leaf trash is flumed away.

KEKAHA DIRECT MOUNTED CUTTER-LOADER FOR IRRIGATED CANE

The design of a one-line, two-way cutter which will deliver the cut cane directly into a self-propelled infield transport has been completed cooperatively by

the Department of Agricultural Engineering and Kekaha Sugar Company. Kekaha has this machine under construction.

EXPERIMENTAL SUCTION DRUM LEAF AND TRASH SEPARATOR

The basic part of the experimental suction drum leaf and trash separator is a revolving perforated cylindrical drum, 3 feet in diameter by 6 feet long, with a DeBothezat axial-flow fan in each end to draw out the air. The suction thus created causes the loose leaf trash to stick to the drum while the cane and attached leaves flow on over. The trash is dropped off at the lower edge of the drum where a stationary dead plate breaks the suction cycle. The complete assembly includes a feed conveyor which delivers the batches of cane trash to the top of the drum.

Tests were made at Hilo Sugar Company on field run cane, and at Olaa on cane from a harvesting experiment. Some of the results of these tests show: (1) that cane containing soil, rocks, stools or mangled stalks reduced efficiency; (2) that cane should be cut in lengths of not over 3 feet for best results; (3) that maintenance of a thin, uniform and continuous flow is necessary for maximum efficiency. Under the best conditions, the average tonnage rate was 30 tons net cane per hour. The trash extraction with cane harvested with standard equipment averaged 65 per

cent. Improved harvesting methods would bring the average up to 80 per cent. About 5 per cent of the cane went out with the trash, due largely to the length of the stalk pieces, since very long or very short pieces tended to stay with the trash. (Figure 33.)

It was found that either wet field cane which contained mud and trash, or field cane full of small leaf trash particles, tended to clog the holes in the drum, so that some means of keeping the drum surface clean must be found.

The drum was also tried in the mill cleaning plant at Kohala (Figure 34). Here small pieces of wet but clean trash stuck to the cylinder, necessitating the addition of scrapers; and some difficulty arose when substantial amounts of soil came in with the trash. It was determined that 60 pounds of cleaner trash can be handled per foot of cylinder length per minute, with a cane salvage efficiency of about 55 per cent. The results have been sufficiently impressive to warrant preliminary design of a permanent installation.



Figure 35. The experimental notched (peg) tooth drum shown after a test run of separating cane shorts from trash.

EXPERIMENTAL NOTCHED (PEG) TOOTH DRUM

An experimental notched (peg) tooth drum was set up to test its efficacy as a separator of cane shorts from mill cleaner trash. The results of the preliminary

operation showed definite possibilities. No conclusive results can be shown until the unit can be tested in a mill cleaner plant. (Figure 35.)

CUTTING CANE FOR DRY CLEANER

Experimental work is in progress at the shop laboratory on ways to reduce stalk lengths of cane flowing in a conveyor. The present problem is to deter-

mine the most promising types of rotary knives to be tried in field machines. The results so far are encouraging. (Figure 36.)

Figure 36. Different types of rotary knives for cutting cane into desired lengths are tested on this hand-fed conveyor.



INFIELD TRANSPORT

The self-propelled track-type infield cane transport unit is being field-tested. The full loads have ranged from 8 to 10 tons, depending on type of cane. The double-ended side-dump body has shown up very favorably. The completed machine weighed

14¾ tons with a calculated ground pressure with load of approximately 5.8 pounds per square inch, and can travel in both directions with speeds ranging from 1.75 to 3.75 m.p.h. Under ideal conditions, the 65 h.p. engine took a full load up a 30 per cent grade.

COOPERATIVE PROJECTS

During the year three projects have been initiated by the Department of Agricultural Engineering in direct cooperation with plantations, namely:

1. A project relative to irrigation flume materials and design. Ewa has installed 36 acres irrigated by plastic flume as an experiment. The observations and results will be compiled for the industry.

2. Howard Rotary Hoe. In testing the Howard rotary hoe, a 7-foot cut unit for direct mounting to the prime mover was procured and attached to a D-7 tractor. The field results have been quite satisfactory,

the machine operating efficiently with as much as 20 tons of leaf trash per acre on the ground surface. Several changes have been required, the most important of which was the building of a new rotor reducing the number of hoe knives from 42 to 28, thus making the rotor self-cleaning under difficult conditions.

3. Louisiana type cane loader. A Thomson "Hurricane" loader was procured to determine the practicability of using a light grab unit for piling hand cut cane and loading into infield transport.



VARIETIES

THE VARIETAL PROCESSION

Sugar cane, like other crops, has had its procession of varieties. The history of the Hawaiian industry in this respect is typical of the cane sugar producing countries of the world. Lahaina held sway in Hawaii during the period of expansion that followed the Reciprocity Treaty of 1876. The opinion was sometimes expressed in those early days that Lahaina would prove unbeatable as a variety for the irrigated lands. By the beginning of the present century, however, Lahaina had begun to show signs of failing, and in time it became necessary to resort to Yellow Caledonia and other substitutes. By 1910 or thereabouts, Yellow Caledonia had displaced Lahaina as the leading variety of the Territory.

Soon thereafter H 109 began its rapid rise, and

in 1924 it displaced Yellow Caledonia from its position of leadership. H 109 remained the leader from 1924 to 1940 when it was in turn succeeded by 32-8560.

32-8560 reached its peak in 1946 with 132,914 acres, the largest area ever to be occupied by a single variety in the history of the Hawaiian industry. Thereafter its acreage began to decline, at first slowly and then more rapidly as newer seedlings better suited to certain districts became available. (Figure 37.)

We are now witnessing the dethronement of 32-8560 by 37-1933. The decline in the acreage of 32-8560 and the rapid rise of 37-1933 should place the latter in the leading position by the end of the present year.

DO SUGAR CANE VARIETIES "RUN OUT"?

The question of deterioration in yield of a variety has been a controversial one for many years. Some have maintained that sugar cane varieties are foredoomed to grow old and wear out. Others have insisted that the genotype of a variety is fixed, and that except for the rare occurrence of deleterious mutations, which could presumably be eliminated by selection, the variety should persist indefinitely without change.

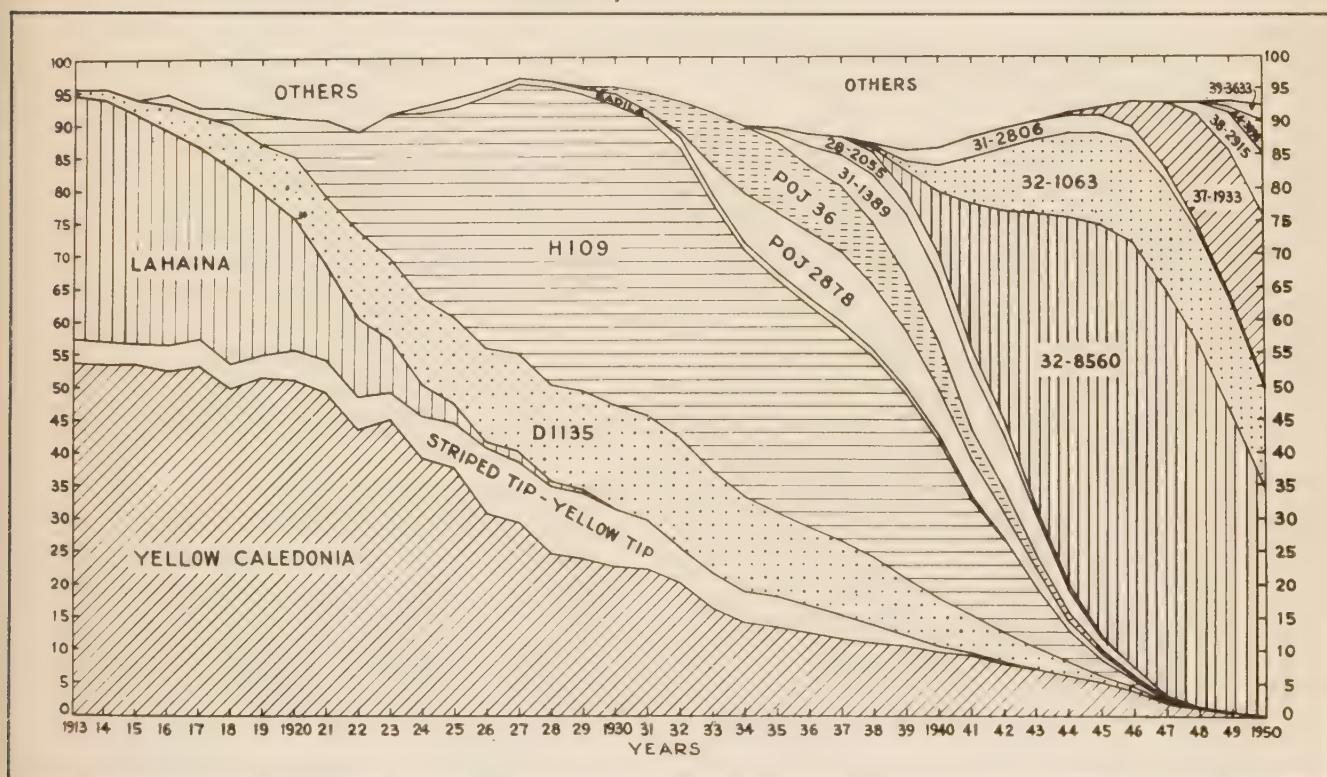
Whatever the cause may be, an eventual decline in yield is the rule rather than the exception whenever a sugar cane variety is grown continuously in the same area, cycle after cycle.

There are several possible explanations for the observed decline in yields. The ability of the soil to support plant growth may be gradually impaired by erosion or by mechanical abuse. Again, a particular variety may eventually exhaust the readily available supply of some essential trace element. And finally, the microbiological component of the environment may undergo a change unfavorable to the variety.

Instances of the latter category are well known in other crops. A new variety of wheat, for example, is proved by exhaustive tests to be resistant to all of the known races of the rust fungi in the area. Because of its rust resistance and its other desirable qualities, this new wheat variety is spread year by year until it occupies many thousands of acres. But presently a hitherto unknown strain of rust makes its appearance—a strain to which this wheat variety proves highly susceptible. Eventually this new strain of rust becomes so widespread and its damage to the crop so serious as to necessitate discarding the variety.

Recent studies of micro-organisms, including viruses, bacteria and fungi, have shown that they are capable of undergoing genetic changes comparable to those long known among the higher plants and animals. These findings have obvious implications for sugar cane. Whenever a single sugar cane variety occupies a large area year after year, it affords an inviting opportunity for any form of microbial life

Figure 37. Varietal changes are here expressed in terms of per cent of total sugar cane area in Hawaii for the years 1913-1950.



that may be able to exploit such a situation. A certain strain of virus, for example, may have been rare when the sugar cane variety was first being spread. But if it is able to multiply at the expense of the cane variety, and if it is provided with some means of dissemination, the virus may eventually spread to epidemic proportions.

The ratoon stunting virus of Queensland provides a classic example. The only recognizable symptom produced by this virus in the cane plant is the failure of the ratoon crop of a susceptible variety to grow normally. The existence of the virus was recognized only when the variety Q 28, which the virus is able to attack, was extended to field scale plantings. It has been demonstrated by the Queensland pathologists

that this virus can be spread from diseased to healthy plants by infected cane knives. It is interesting to note that its presence is usually associated with poorer soils.

What is the useful life expectancy of a new variety? Even in the absence of new competitors, varieties are likely to differ in respect to their longevity. Yellow Caledonia remained an important variety for 50 years. In Queensland and Fiji, Badila has been able to maintain its position for a like period. POJ 36, on the other hand, declined rapidly in some districts. It is impossible to predict how soon a new variety will be overtaken by negative factors. Nor is the decline of a variety likely to proceed at a uniform rate throughout the whole of its range.

BREEDING FOR RESISTANCE TO DELETERIOUS FACTORS

What assurance is there that a new mutant virus or any other negative factor, biological or otherwise, can be dealt with by breeding and selection? There can be no guarantee of success in this direction. It is certain, however, that varieties will vary in their sensitivity to any negative factor. It is also certain

that the broader the base of the breeding program, in other words, the greater the diversity of the parent material at the disposal of the breeder, the greater the likelihood of discovering individuals that are resistant to whatever negative factors may be encountered.

THE BREEDING COLLECTION

The breeding collection is constantly being strengthened by new additions. These come from two sources:

1. The regional station testing program which brings to light each year individuals having desirable traits. These are tested in the breeding program for their ability to transmit desirable qualities to their offspring.

2. The importation program. Under strict quarantine, importation of breeding canes was initiated in 1923 and intensified following World War II. Since the resumption of the program in 1945, some 20 varieties per year have been imported through quarantine from other parts of the world, and tried in the breeding program.

The more important breeding canes of each of these two categories are listed below:

(1) Superior breeding canes of local origin:

31-1389	37-7202	41-1156
32-6705	38-2915	41-1181

32-8560	38-5501	41-3340
32-9624	39-723	43-1616
34-1874	39-3633	43-1884
35-198	39-5747	44-2818
36-6496	39-5803	44-3098
37-349	39-7028	44-3114
37-1933	40-1179	47-4991
37-6819	40-1184	

(2) Foreign breeding canes:

B 34104	} from the British West Indies Central Sugar Cane Breeding Station, Barbados.
B 37161	
B 4098	

Co. 213	} from the Coimbatore Breeding Station, South India.
Co. 270	
Co. 290	
Co. 301	
Co. 331	
Co. 413	
Co. 421	

C.P. 29-116 }
 C.P. 29-120 }
 C.P. 29-320 } from the USDA Breeding
 C.P. 34-79 } Station, Canal Point, Florida.
 C.P. 34-120 }
 C.P. 36-105 }
 D 14-34) from Demerara (British Guiana).
 F 108 }
 F 113 } from Formosa.
 M 134-32) from Mauritius.
 POJ 2878 }
 POJ 2967 } from Java.
 POJ 3016 }
 Trojan }
 33 MQ 157 } from CSR Co., Australia.
 Korpi } a "noble" cane from New Guinea
 via Australia.
 Burma spontaneum) a wild cane from Burma.
 Port Moresby robustums } wild canes from
 New Guinea.
 Uganda spontaneum } wild canes from cen-
 Mbeya spontaneum } tral Africa.
 Uba Marot) a half-wild cane from Mauritius.

Many of the above listed foreign varieties have already been crossed with Hawaiian varieties. But few, if any, of the first generation hybrids from such crosses can be expected to qualify as commercial possibilities under local conditions. It is usually necessary to backcross the hybrids at least once to Hawaiian varieties in order to obtain even a few individuals that possess the second-season growing power and the carry-over ability requisite for success under a system of two-year cropping.

The populations of seedlings resulting from crosses between Hawaiian varieties and foreign canes are on the whole strikingly inferior to the populations obtained by crossing local varieties among themselves. It is likely that progress in the immediate future would be more rapid if the breeding were confined to crosses among superior Hawaiian breeding canes. However, such a policy would close the door to the possibility of still greater long-term gains to be realized by extracting desirable traits from other blood lines.

It is the responsibility of the breeder to explore the gamut of available breeding material and to sift out from among the bulk of undesirable traits those few plus factors that may lead to higher levels of sugar production.

INSURANCE ASPECT OF THE BREEDING PROGRAM

By no means all of the wide range of material in the breeding collection will prove immediately useful. The breeding collection may be likened to a tool kit that is held in readiness to meet whatever need may develop. It provides a reservoir of variability upon which the breeder may draw in developing new types to meet new requirements as they arise.

A similar element of insurance is provided by the many seedlings that approach, but do not quite attain, commercial status. If any one of the major

varieties should begin to decline there will always be, under the present breeding program, a group of standby varieties that are pressing the leader for first place and that could be substituted with but little loss in yield. Thus 37-1933 could be replaced in certain makai areas by 39-5803 and in certain mauka areas by 39-2915 and 44-3098. A list of other standby varieties, which in case of necessity could serve in limited areas as substitutes for 37-1933, include 38-5833, 39-3633, 39-7028, 40-1184 and 45-2120.

THE TASSELING PROBLEM

It is well known that sugar yields are depressed by heavy tasseling. "Cutting back" in July to escape first-season tasseling was widely practiced in the early days of the industry. Cutting back cannot, however, provide a satisfactory solution to the problem, since it prevents tasseling only at a sacrifice in growing time and entails a high labor expenditure.

Tasseling can also be prevented by night lighting during the critical differentiation period. Whether enough illumination to prevent tasseling can be supplied economically on a field scale is still to be determined.

Still another line of attack is the breeding of light-tasseling or non-tasseling varieties. One diffi-

Figure 38. Variety 39-7028 was sprayed nine times between August 17 and September 15 with several chemicals. All produced lalas in a large percentage of the stalks. Two typical cases are shown: the one on the left received triodobenzoic acid, and the one on the right received coumarin.

culty in this direction stems from the fact that among the offspring of medium- and heavy-tasseling parents only an occasional light tasseler or non-tasseler is found. Only by growing large populations of seedlings has it been possible to find even a few individuals that combine freedom from tasseling with the other essential qualifications.

For rapid progress in breeding toward freedom from tasseling, tassels in quantity from light-tasseling and "non-tasseling" canes are needed. Various hormones and other treatments have been tested in an attempt to discover a practical means of inducing the "reluctant" tassellers to produce tassels for use in breeding, but none has thus far proved effective.

Flower induction in the reluctant flowering varieties was attempted at Kailua last year cooperatively by the Departments of Genetics and of Physiology and Biochemistry. Chemicals known as anti-auxins were sprayed on varieties BH 10/12 and 39-7028. No flowers were produced in either variety, but 39-7028 showed the interesting response of producing lalas, just as though flowering had taken place. Apparently, a hormone shift had activated the lateral buds without actually stopping vegetative growth of the terminal bud. Up to 50 per cent of the treated stalks were induced to lala. (Figure 38.)

Some progress is being made by planting larger areas of the light-tasseling parent varieties in certain spots at Maunawili, a section of the breeding station where conditions are particularly favorable for tasseling. In this connection, a fortunate acquisition this year was an additional nine acre tract at Maunawili in exchange for an equivalent area of Kailua valley bottom land that has proved unsatisfactory from the standpoint of tassel production. It is anticipated that the new Maunawili area will become an important



asset in providing tassels of light-tasseling varieties, thereby furthering the program of breeding toward freedom from tasseling.

Plantation field plantings of light-tasseling varieties provide still another source of tassels for use in breeding. Even though the percentage of tasseling in the field may be extremely low, the total number of tassels obtainable from a large field is sometimes considerable. From such plantings, several hundred tassels of 39-7028 were obtained this year, from which several thousand seedlings have been germinated. The cooperation of the Kauai and Oahu plantations in supplying these tassels is gratefully acknowledged.

Although the percentage of light tassellers in present day populations of new seedlings is still relatively low, it is nevertheless rising gradually. This is presumably resulting from the cumulative effect of many years of selection pressure in this direction, and from the consistent utilization in the breeding program of tassels from light-tasseling parents whenever and wherever obtainable.

REVIEW OF 1951 SEEDLING PERFORMANCE

37-1933 continues to set a high standard under the favorable conditions of the better leeward irrigated lands. It is due for further expansion under these conditions—there are still some 15 or 20 thousand acres of 32-8560 in areas that will produce more sugar when converted to 37-1933.

From the standpoint of sucrose content 37-1933 is one of the best. Its quality ratio tally reads Good 108, Average 136, Poor 4.

38-2915 has proved its worth under conditions of hardship. Included under this heading are:

1. the growth failure areas of central Maui
2. thin soil areas in the mauka irrigated lands
3. the middle and upper unirrigated lands of Hamakua, Kohala, and windward Kauai
4. droughty shallow soil areas in the makai lands of Kau, Hamakua, and Kohala

Because of its tendency toward poor juices (QR tally = Good 14, Average 211, Poor 81), 38-2915 is not at its best under conditions that favor rank cane growth. It is particularly at a disadvantage where ripening cannot be adequately controlled.

39-3633 remains a strong competitor in the irrigated middle belt lands of windward Kauai where its light tasseling is a decided asset. Except for its unreliable germination when planted late in the season, it would also be spread more extensively in the makai lands of the Hilo district. Since it is not a strong second-season grower it will probably have to be cropped at 16 to 20 months for best results. 39-3633 has an average QR tally—Good 46, Average 187, Poor 47.

39-4753 is a special purpose cane for the middle and upper lands of Hamakua and Kohala where it has come through with consistently good yields. It appears to have possibilities also in the middle and upper lands of windward Kauai. Whether or not it can hold its own with other competitors such as 38-2915 remains to be seen. In any case, it is a good standby variety for these conditions. It has an average QR tally—Good 10, Average 39, Poor 9.

39-7028 is at its best in the poor mauka lands of windward Kauai where its freedom from tasseling and its strong second-season growth are important advantages. Its chief weaknesses are its protruding eyes which make for poor stands in plant cane, its spotty ratooning, and finally its tendency toward poor

juices (QR tally = Good 8, Average 96, Poor 56). These weaknesses would long since have disqualified 39-7028 were it not for its remarkable yields at harvest under the toughest conditions of windward Kauai. For long cropping under these difficult conditions nothing has yet been found to equal it.

41-3340 has a good QR tally (Good 35, Average 71, Poor 6) and a record of excellent drought resistance. Except for its open habit and heavy tasseling, it would undoubtedly have become an important variety in the middle and makai lands of Hamakua and Kohala. It may still find a place in the makai Kau lands where drought is a major problem and where tasseling is not excessive.

44-3098, although remarkably versatile, is not without its limitations. It has been unable to equal 37-1933 in the best makai lands of the leeward districts where favorable conditions lead to rank growth. It is not quite hardy enough to outyield 38-2915 and 38-4443 in the poorer mauka lands of Hamakua and Kohala. It has failed to equal 39-7028 in the poorer mauka land of windward Kauai. Elsewhere, however, 44-3098 is a strong competitor. It has outyielded 37-1933 on several occasions in the heavy tasseling windward districts, where its somewhat lighter tasseling gives it an advantage. It has also outyielded 37-1933 in the poorer mauka fields of the leeward districts. It has been particularly outstanding in the middle and upper lands of Hilo and Kau. Information as to the yielding ability of 44-3098 in ratoons is still scanty. Its QR tally is average (Good 27, Average 80, Poor 23).

45-2708 is of particular interest in the heavy tasseling windward districts where its relative freedom from tasseling should prove advantageous. It is hardly likely to compete with 37-1933 under good leeward conditions. Its chief faults are its spreading habit in the early stages of growth which leads to damage from herbicides and cultivators, and its deficient stooling. However, it is a strong second-season grower and it has come through under long cropping in sound condition. Its QR tally thus far includes only nine harvestings. These are distributed as follows: Good 4, Average 5, Poor 0.

46-551 appears to be at its best in middle and lower lands of the Hamakua district where drought is not a problem. It merits preliminary testing also

in the mauka unirrigated lands of windward Kauai. It is a strong grower in the Hilo district, but under wet conditions it has proved to be somewhat susceptible to chlorotic streak. In the leeward districts it frequently develops symptoms of Pokkah Boeng. Its QR tally is average (Good 5, Average 7, Poor 3).

47-4991 is still in the preliminary stages of testing. It is a fast starter and a remarkably strong first-season grower throughout the windward district, where it is being widely tested and moderately spread.

Its freedom from tasseling is an important asset. Its growth tends to slacken during the second season; it may have to be harvested at 18 to 20 months for maximum acre-month yields. Since it has not yet been harvested for yield data, no QR figures are available. Its Brix tally at 12 months is only fair (Good 3, Average 28, Poor 9). 47-4991 does not thrive on the alkaline makai soils of the leeward districts. However, it appears to be worthy of testing on the more acid soils of the mauka leeward lands.

PRELIMINARY TESTING ON PLANTATIONS

The intensification of the breeding program since the end of World War II has provided a large and promising group of candidates for plantation testing. We refer particularly to the 47-, 48- and 49- series.

Table 4 shows the number of preliminary tests (10 x 15 and 30 x 30) installed by the plantations during the past year. The corresponding totals for the four preceding years are included for comparison.

It is gratifying to note that the number of 10 x 15 tests shows a steady rise. While the number of 30 x 30

tests has not shown a corresponding increase, the number of such tests reached a new high in 1950-1951.

Table 4. Number of Preliminary Tests Installed by all Plantations (For fiscal year ending June 30, 1951).

Type of Test	1946-47	1947-48	1948-49	1949-50	1950-51
10 x 15	25	50	54	62	70
30 x 30	8	30	41	47	50

BI-PARENTAL CROSSING GIVEN GREATER EMPHASIS

The crossing campaign was begun on November 17, 1950 and concluded on January 11, 1951. The number of crosses completed during the season was 2808. During the preceding year 3222 crosses were completed. This year's reduction of 414 crosses has resulted from a curtailment of melting-pot crosses in order to permit the expansion of bi-parental crossing which has a higher man-hour requirement.

A total of 4185 flats was distributed from the

Makiki greenhouse to the regional stations. An additional 206 flats were sent to plantations interested in finding varieties for special conditions. The total number of flats distributed during the preceding year was 5179. The reduction of 788 flats resulted from the expansion of bi-parental crossing which necessitated a considerable reduction in melting-pot crossing. Germination from bi-parental crosses is consistently lower than from melting-pot crosses.

COOPERATIVE VARIETY TESTING

The number of replicated tests installed by the plantations during the year is shown in Table 5.

It will be noted from the table that replicated testing on the plantations has declined for the second successive year. This decline is accounted for only partly by a shortage in some districts of acceptable candidates for Grade A testing. Such a situation, where it exists, calls for an intensification of the 30 x 30 testing program with the object of discovering

candidates for Grade A testing. It should perhaps be pointed out that there is no dearth of candidates for 30 x 30 testing.

A major obstacle standing in the way of both 30 x 30 and Grade A testing is the lack of an acceptable means of harvesting these tests mechanically. A suitable harvesting unit should reduce the cost of harvesting field experiments and should improve the accuracy of the results.

ACREAGE CENSUS OF CANE VARIETIES

The total area in cane as of December 31, 1950, was 216,237 acres, reflecting a gain of 3966 acres over the preceding year. The plantings during 1950 totalled 42,835 acres, an all-time record for the industry.

With 12,000 acres for the year, 37-1933 heads the list of varieties planted. If the present varietal trends are maintained, 37-1933 will become the lead-

ing variety of the Territory by the end of 1951.

38-2915 stands second with 8453 acres planted during 1950, followed closely by 44-3098 with 8049 acres. 32-8560 has dropped to fourth place with only 6120 acres planted during the year. Listed in descending order, other varieties accounting for more than 100 acres planted are: 32-1063, 39-7028, 40-1179, 38-4443, 41-3340, 39-4753, and 38-4744.

Table 5. Replicated Variety Tests Installed by Plantations July 1, 1950 to June 30, 1951.

Variety	Kauai	Oahu	Maui	Hawaii	Total
31-2484	....	..	...	1	1
32-1063	....	....	....	5	5
8560	1	....	....	8	9
37-1933	7	1	....	1	9
38-2915	3	1	..	11	15
4443	....	....	....	5	5
4744	....	....	....	3	3
39-723	....	....	....	1	1
3633	2	....	....	12	14
4753	2	....	....	5	7
5803	1	....	....	....	1
7028	2	1	....	2	5
40-1179	....	....	....	1	1
1184	....	1	....	....	1
41-3340	....	....	....	7	7
6789	....	....	....	1	1
6800	....	....	....	1	1
44-720	....	....	....	1	1
2576	1	....	....	....	1
2772	....	....	....	1	1
3098	6	2	....	21	29
45-2120	....	....	....	2	2
2708	4	1	....	3	8
46-551	....	....	....	9	9
1463	1	....	....	....	1
1562	1	....	....	....	1
1734	1	....	....	....	1
47-4991	....	....	....	7	7
TOTALS					
1950-51	32	7	0	108	147
1949-50	86	19	5	89	199
1948-49	103	12	14	144	273

JOHN WARNER TO AUSTRALIA AND NEW GUINEA

J. N. Warner, Senior Geneticist, spent the period from April 2 to July 21 in Australia and New Guinea, with a stop-over in Fiji en route. The purpose of these travels was to gain familiarity with the breeding procedures and philosophies of the Australian sugar cane breeders and to collect new breeding material.

Mr. Warner was in New Guinea at the same time as were Messrs. Buzacott and Hughes of the Queensland Bureau of Sugar Experiment Stations. An extensive area was covered in the New Guinea highlands in most of which no sugar cane collecting had

previously been done. Some time was also spent at lower elevations. (Figures 39-43.) Upon returning to Australia from New Guinea early in June, Mr. Warner devoted the remainder of his stay to a study of the breeding and testing programs of the Bureau of Sugar Experiment Stations and of the Colonial Sugar Refining Company.

The fuzz from tassels of breeding canes collected in New Guinea and of crosses made in Queensland have been germinated under quarantine in the Mapulehu greenhouse.





Figure 39. Year-old noble canes in a native garden near Port Moresby, Papua. Fuzz was collected from representative wild canes for propagation under quarantine on Molokai.

Figure 40. A clump of *Saccharum robustum* on the bank of the Laloki River, near Port Moresby. The canes were 15 to 20 feet high, one to 1½ inches in diameter, and in flower. The man in the foreground is over six feet tall.

Figure 41. Construction of a "pit-pit" fence (*S. robustum*) is one of the uses to which wild sugar cane is put by the natives of the Central Highlands of New Guinea. As many of the stalks germinate, the fence usually becomes a hedgerow.

Figure 42. Method of planting sugar canes (*S. officinarum*) in a native garden near Mount Hagen, Central Highlands of New Guinea. Sugar cane is grown solely for chewing purposes in New Guinea.

Figure 43. J. H. Buzacott, leader of the 1951 expedition to New Guinea, and Senior Plant Breeder for the Bureau of Sugar Experiment Stations, Queensland, taking a Brix reading in a native garden in the Central Highlands of New Guinea. Over 100 noble canes were collected in this area and are growing in quarantine in Brisbane, Australia.





WATER DEVELOPMENT

TEST DRILLING AT WAILUKU INDICATES SITE FOR DOMESTIC WATER DEVELOPMENT

Since the completion in 1947 at Wailuku, Maui, of the inclined shaft which taps the Wailuku basal ground-water body, the possibility of developing water from the same ground-water body for the supply of the towns of Wailuku and Kahului has been discussed. Because of the interest of Wailuku Sugar Company in this domestic supply, the Geology Department has guided the prospecting for a suitable site for the development.

The Wailuku basal ground-water body is a Ghyben-Herzberg body lying in the steeply dipping lava flows of the Wailuku volcanic series on the west side of the West Maui dome. Its discharge to the perimeter of the dome is restricted by a series of alluvial fans partly filling the valleys cut in the dome and coalescent around the ridges between these valleys. Because of this restriction, the water level in the body is nearly 30 feet above sea level. The fans are dissected by the present stream valleys.

A site had to be selected near Wailuku where, first, the well constructed would penetrate the lavas of the Wailuku series near sea level, and where, second, the well collar, or portal, would be lower than the portal of the Wailuku inclined shaft to save on pumping head. The meeting of both requirements offered some difficulty. Both the contact of bedrock lavas with the overlying alluvium and the surface of the alluvial fan dip westward, and the alluvium-bedrock contact is the steeper. The portal of the Wailuku shaft could not have been located much farther seaward on the alluvial fan to lower the portal elevation without the incline failing to penetrate the lavas above sea level, and a drilled well at the same site would have met the lavas far below sea level. Furthermore, there was a strong possibility that the bedrock surface had been eroded locally before the deposition of the conglomerate either by streams or the sea.

The incision of Iao Valley below the level of the

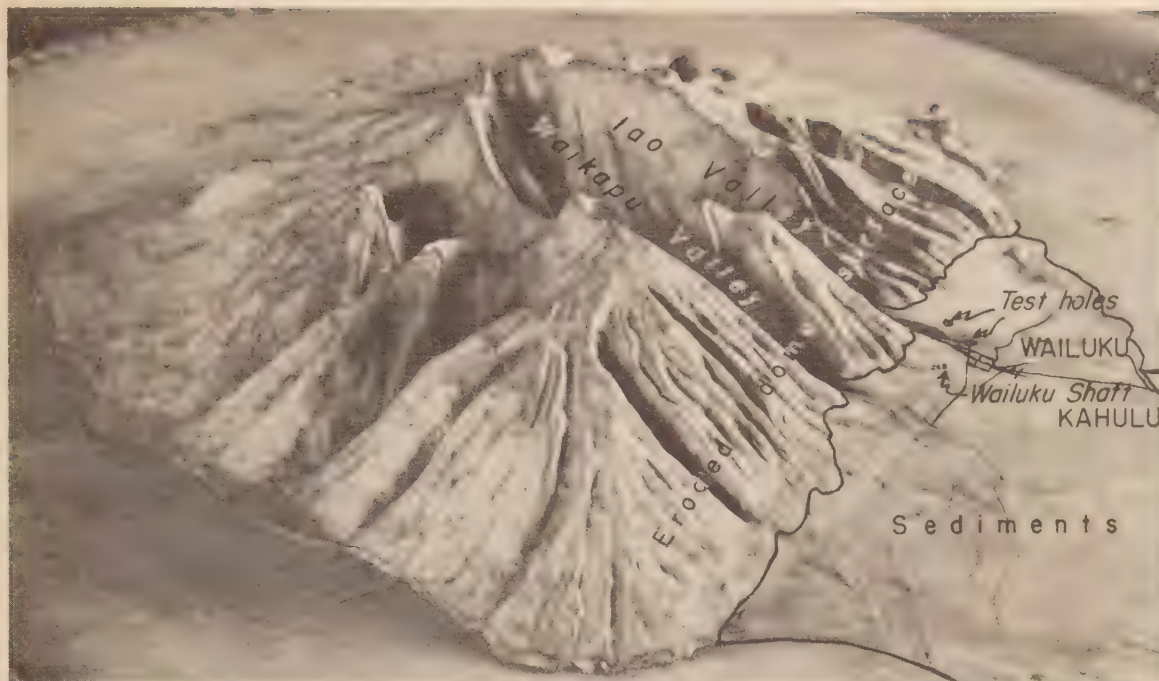
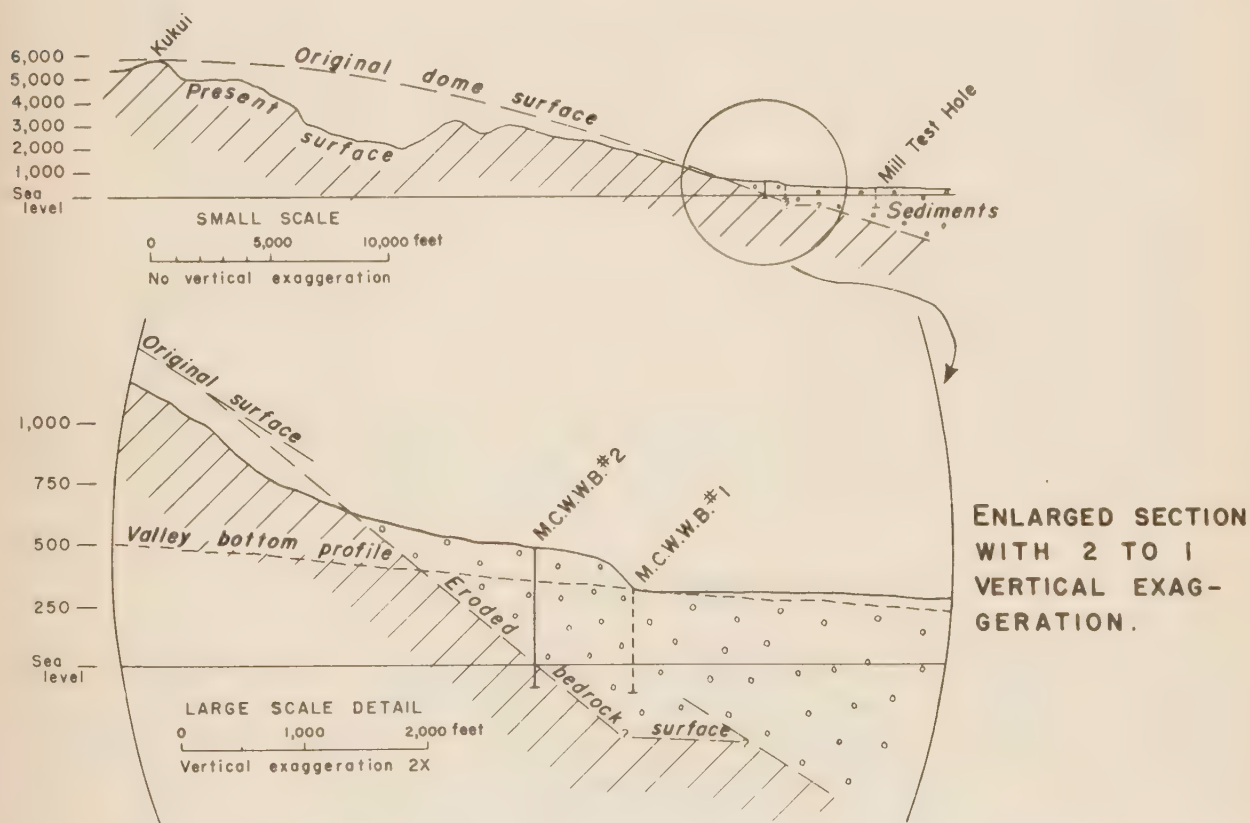


Figure 44. The model at the University of Hawaii of the east flank of the West Maui mountains is vertically exaggerated about two and one-half times, and shows the relation of the test holes to geology.

Figure 45. Diagrammatic section through Wailuku test holes, showing the buried bedrock surface.



DIAGRAMATIC SECTION THROUGH WAILUKU TEST HOLES
SHOWING BURIED BEDROCK SURFACE

alluvial fan suggested a means of keeping the well site low but yet far enough mountainward to meet the bedrock at sea level or above. A fortunate bend in the valley provided an area of valley bottom that would expectably lie north of a possible buried bedrock valley. Two test holes were drilled to ascertain the position of the bedrock surface and to investigate its permeability and the level of the water in it. (Figures 44-45.)

These holes have indicated that even off to the side of the possible buried bedrock valley, the bedrock surface lay lower than expected, indicating prob-

able marine erosion, but also indicating that bedrock could be reached either by a gently inclined shaft from Iao Valley, or by drilled wells tapped by a tunnel from the valley. The holes also demonstrated high-level water in the conglomerate that would make construction of a shaft very difficult.

A system of drilled wells a few hundred feet north of Iao Valley, with a tunnel connecting them horizontally to the valley, has, therefore, been recommended for the Wailuku domestic supply. Testing the possible utility of the high-level water found in the gravel has also been recommended.

DESIGN OF INCREASED CAPACITY OF PAAUILO WELL AIDED BY TIDAL ANALYSIS

The Maui-type well constructed at Paauiilo, Hawaii, in 1945, has proved inadequate to supply the total mill and domestic demands. A pumping test was made in January to determine the present specific capacity as a guide to estimating additional development necessary to supply the total demand. In analyzing the results of this test, the method of tidal analysis worked out in cooperation with personnel of the Scripps Institution of Oceanography, proved invaluable. The water level record of the test (Figure 46) is dominated by tidal fluctuation, but the analysis made possible the extraction of a drawdown record

that indicated adequately the specific capacity.

All available hydrologic data were compiled for the Paauiilo and adjacent areas to the range of conditions expectable. In connection with this compilation, recommendations were drawn up that will increase the utility of the records kept in the future. The study of the range in tidal and climatic fluctuations to be expected at Paauiilo indicated that at some times the capacity of the well would probably be more limited than at any time so far experienced, but that the desired future capacity could be attained with about 50 per cent increase in infiltration tunnel length.

WELL CONSTRUCTED AT LAWAI

The 1950 program of diamond-drill exploration at Lawai, Kauai, for a source of basal ground-water for irrigation led to the discovery that the Waimea Canyon series of lava flows, in which the water was sought, was sharply cut off near Lawai Cannery. A site with as low a delivery elevation as possible was selected for a drilled well to serve both as a continuing source for the cannery and as a test well to determine additional capacity for McBryde Plantation. This

well has now been completed, and has been found to produce one million gallons per day with a drawdown of two feet. Tests of the capacity of the aquifer are expected to run for many months at least.

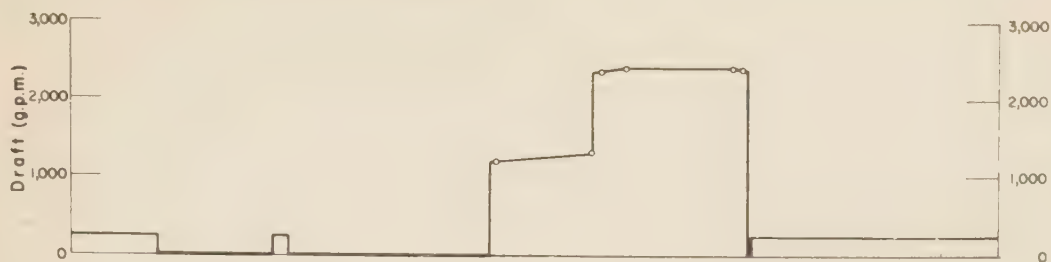
A similar site near Koloa Mill has been selected for testing as a possible source of irrigation water for Grove Farm. Hydrologic testing is required because a number of dikes in the vicinity may restrict flow of water toward the site.

FIRST DRAFT AT HONOKOWAI

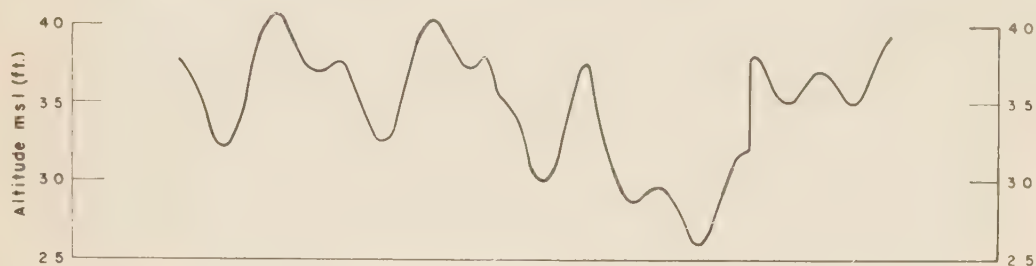
Pioneer Mill's new Maui-type well at Honokowai, Maui, has been pumped at a rate of 10 million gallons per day with a drawdown of 2.2 feet. This is nearly the limiting drawdown when the static head is high, and the capacity of the well may be lower when the

static head is low. The salinity increased from 4 to 10 grains of NaCl per gallon in the first two weeks of pumping. Because of the low head at this well, about two feet above sea level, the salinity will be observed critically for some time.

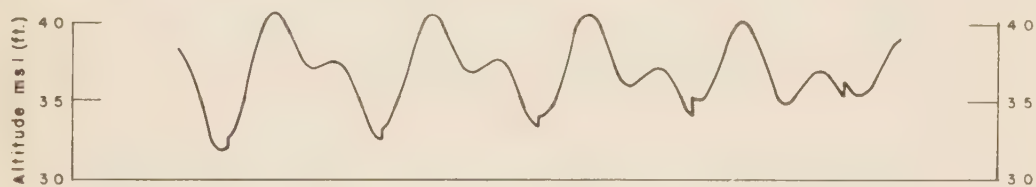
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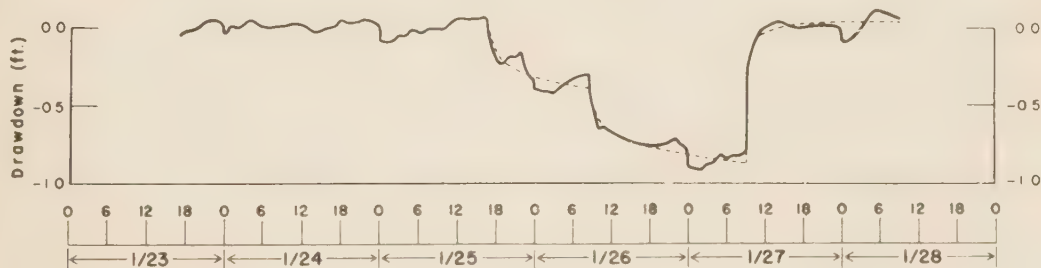
THE WATER LEVEL FLUCTUATED LIKE THIS:



BY SUBTRACTING THIS TIDAL FLUCTUATION:



THE DRAWDOWN WAS COMPUTED AS SHOWN:



TEST RESULTS AT PAAUILO WELL

Figure 46. Test results at Paauiilo Well.



Figure 47. Man-made cumulus cloud over cane fire at H. C. & S. Demonstrations such as this indicate possibilities of ultimate control of rainfall.

WEATHER

RAIN CONTROL RESEARCH STIMULATED BY NEW DISCOVERIES

During the past year significant research has been reported in the scientific journals on two phases of the problems of rainfall control in warm climates. The first of this work was done by A. H. Woodcock, a scientist working at Woods Hole Oceanographic Institution in Massachusetts. He found that microscopic sea-salt particles were of primary importance in the formation of raindrops in warm clouds; i.e., clouds warmer than freezing.

The implications in this work are that the introduction of the proper size of sea salt or other hygroscopic particles in great numbers will either increase or decrease rainfall under certain circumstances. The

effects of cane fires in forming clouds in Hawaii are already well-known (Figure 47).

A paper was recently published in a French geophysical journal which described seeding warm clouds, with promising results, by a solution of sodium chloride or calcium chloride.

Because nearly all clouds appearing in the skies over Hawaii are "warm clouds," this research stimulated the interest of the scientists in the activities of the Meteorology Department. Mr. Woodcock came to Hawaii for a month to confirm some of his measurements of salt particle sizes and their relationship to rainfall here. (Figures 48 and 49.)

NEW MONTHLY WEATHER REPORT GIVES PAST AND FUTURE DATA

Beginning in December 1950, a new monthly weather report has been published by the Meteorology

Department with the cooperation of the U. S. Weather Bureau. This report is designed to give a synopsis



Figure 48. A. H. Woodcock, of Woods Hole, Massachusetts, measuring salt content of Hawaiian rains. Salt is important factor in formation of rain-drops.



Figure 49. Adjusting apparatus for catching and measuring microscopic sea-salt particles at various altitudes and locations in Hawaii.

of weather conditions for the Territory throughout the crop, and to present the weather outlook and statistics for the coming month.

The report includes rainfall maps for each island for the past month and for a three-month period. It also tabularizes the temperature data according to its favorable aspects for cane growth for past periods of one month, three months, six months, etc., up to 24 months. Rainfall is similarly tabulated for selected stations throughout the Territory.

Included with these data is the month-ahead fore-

cast, giving the best prediction available, including a statement of the likelihood of very rainy or very dry conditions based on past records alone. (Figure 50.)

On the back of the report are charts and graphs showing the average rainfall for different areas in the Islands and the average number of times that yearly totals exceed the averages for the same areas.

Since the report has been found helpful in both the sugar and pineapple industries, the 1952 series will include additional information.

NEW INSTRUMENT FOR STUDYING CANE DEVELOPMENT IN RELATION TO TEMPERATURE

A new instrument (Figure 51), which not only records the temperature continuously throughout the day but also averages it, was produced in collaboration with P. S. Pell and Company by combining two instruments which were made for other purposes: a "flow meter", which is a device for recording flow through a pipe; and a standard thermometer. By com-

binning these, the "flow meter" keeps a record of the total accumulation of "hour-degrees" of temperature.

The instrument requires standard 110 V power for operation and costs approximately \$300. It should prove valuable for studying the rate of cane growth under various natural conditions on the different plantations.

Figure 50. Extreme weather conditions such as those experienced in March, 1951, are summarized in the Monthly Weather Report to make a permanent record for plantations.



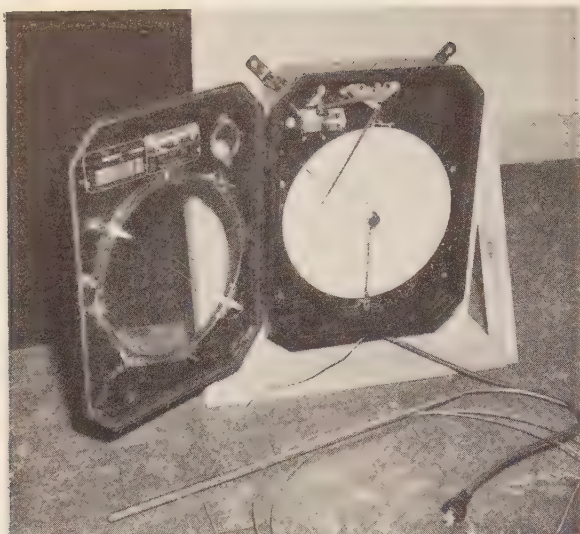


Figure 51. New instrument for recording and accumulating temperature units in relation to cane growth.

WEATHER RECORDS PROGRAM NOW IN FOURTH YEAR

Beginning in January 1948, a program was initiated by the Meteorology Department to collect and bind for reference and research purposes all weather records which are currently being kept in the Territory. Up to that date there was no single agency which had undertaken such a program and a great many reliable records had been lost.

By supplying to plantations and cooperators record books with removable carbon copy sheets, the

Meteorology Department is now able to collect the records from 875 rain gauges throughout the Territory. Approximately 200 of these stations are being processed by I.B.M. punched cards for the preparation of published U.S. Weather Bureau reports. These cards are now available in the Meteorology Department for research purposes by departments of the Experiment Station and the Pineapple Research Institute, as well as by individual plantations.

WEATHER FORECASTS CONTINUE TO IMPROVE

Calculations of the accuracy of weather forecasts in the Territory for the past 12 months indicate a steady improvement (Figure 52). The graph shows the improvement of 24-hour weather forecasts over 1949-1950. These figures are derived from the quantitative rainfall forecasts which are made each morning to cover the next 24 hours for areas on Oahu and Kauai. The forecasts are compared with the verifications made in these areas by the plantations, and are forwarded at the end of each month to the Meteorology Department.

Because of the qualitative character of other factors in the weather forecasts, such as cloudiness or general trends in the weather, no attempt has been made to evaluate them. In general, however, the accu-

racy trends in predicting these factors would be similar to those for rainfall, temperature or wind, where numerical values can be given.

The long range weather forecasts prepared by the Extended Forecast Section, U.S. Weather Bureau, Washington, D.C., in cooperation with the Meteorology Department, have also continued to show improvement. Progress has been slow, however. Figure 53 is a graph of the accuracy of these forecasts as applied to selected gauges on Kauai and Oahu. The accuracy continues to be best for these northernmost islands, and also for drier areas and for winter months. Forecast accuracy is markedly less for stations located in wet zones, and for all stations during the summer months.

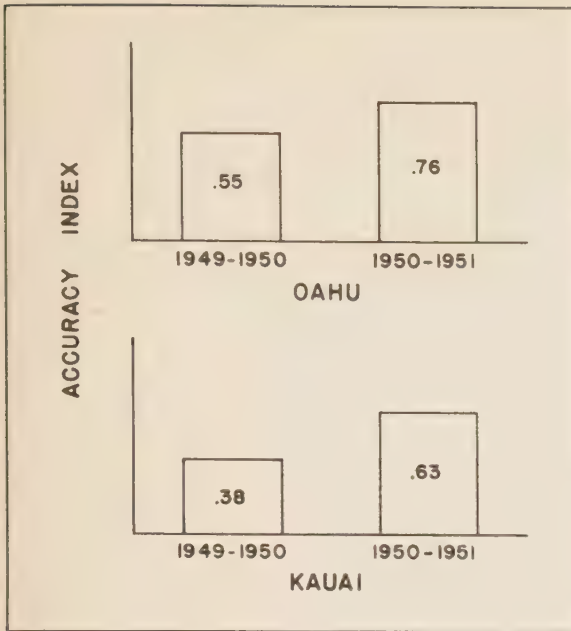
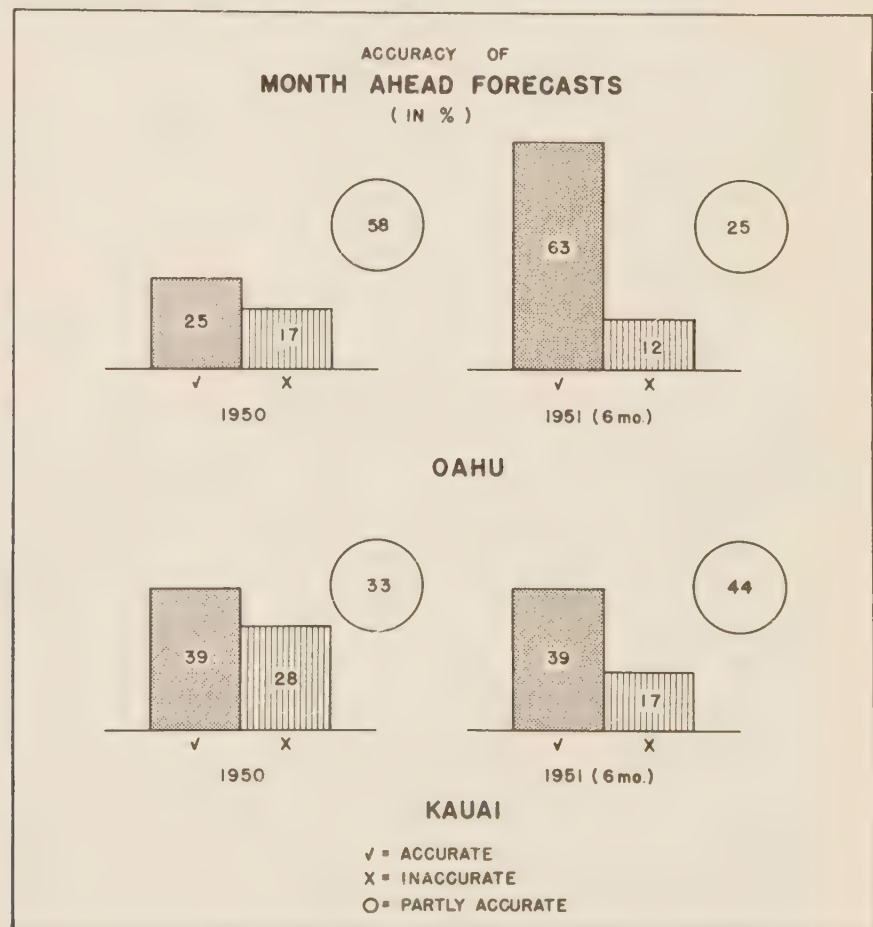


Figure 52. (Left) Twenty-four hour forecasts on Oahu and Kauai show improvement in accuracy during the past 12 months.

Figure 53. (Below) Accuracy of forecasts as applied to selected gauges on Kauai and Oahu.



WEATHER FORECASTS NOW MADE ON 63 RADIO BROADCASTS WEEKLY

Radio broadcasts of weather information from the District Forecast Office of the U.S. Weather Bureau at the Honolulu Airport are regularly scheduled by five stations on four islands. These are up to the minute summaries of weather conditions, forecasts of wind, temperatures, cloud conditions and rainfall for the next 24 hours, and forecasts of sea conditions. Also included are quantitative forecasts of rainfall conditions for the Territory which are useful to plantation personnel in scheduling operations.

The development of this program is part of the cooperative arrangements between the U.S. Weather Bureau and the Meteorology Department. Work is progressing both in Washington, D.C., and in the District Forecast Center in Honolulu for the extension and improvement of the weather forecast program. Research toward improving the accuracy of short range forecasts is done cooperatively by the Meteorology Department and the U.S. Weather Bureau Research Forecaster.

SPRAY DRIFT PROBLEMS RELATED TO WEATHER

Because 2,4-D is still one of the best chemical weed control agents available, considerable savings could be made by plantations in certain spray drift danger areas if drift could be eliminated. The problem of drift is essentially meteorological involving wind, drop size, evaporation, and dispersal by the turbulent mixing of the air.

During the spring and summer, the Meteorology Department in cooperation with the Agronomy Department made studies of local factors affecting the wind, temperature, humidity and air currents, and

measured the drop sizes from aircraft spray and ground spray equipment. One purpose of these studies was to determine whether or not there were limiting meteorological factors which might prevent damage from spray drift under specific weather conditions.

Results are incomplete, but have been encouraging. Certain facts have been dramatically demonstrated concerning the differences in weather conditions as they affect spray operations from morning to afternoon on plantations on slopes of the large mountains on Hawaii and Maui. (Figure 54.)

Figure 54. Simulated spray drift using smoke generators at Hutchinson. The smoke was visible much farther downwind during early morning hours than in the afternoon.



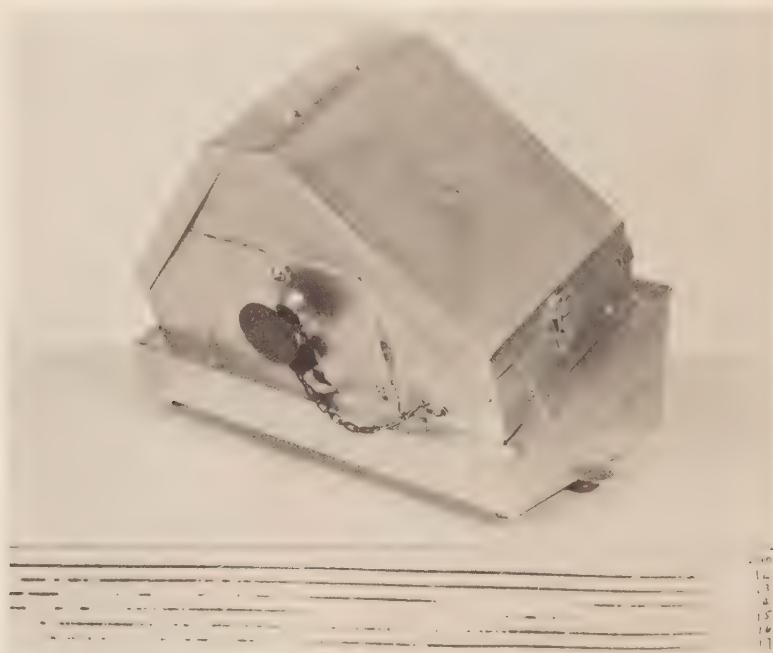
METHODS FOR MEASURING SOLAR RADIATION BEING IMPROVED

Some years ago the blueprint sunshine recorder for obtaining a record of the daily hours of sunshine was developed at the Station by the Department of Climatology, but because its recording paper had to be changed daily, it was not a practical field instrument for plantation use. Improvements have been made so that the recording paper is now mechanically changed and needs attention only once a week. Two types of changing mechanisms have been developed, an electric model for use at village sites and a spring-driven model for remote field stations. Each unit costs less than \$15.00. The sunshine recorder and the type of record it keeps are shown in Figure 55. From this record the total number of hours of sunshine may be

determined for a weekly period, since the line which records sunshine is broken whenever the sun is obscured by clouds.

With few exceptions, the plantations obtain air temperature data by means of maximum and minimum thermometers. By this means, only the two extremes of temperature are obtained. A more desirable method of expressing temperature would be an integrated value which includes the element of time. Instruments which will accomplish this are available but they are either expensive or not adapted to field use. Work is under way to develop a simple, inexpensive field instrument for the integration of temperature.

Figure 55. The Blueprint sunshine recorder and the record it keeps.



TEMPERATURE CONTROL CHANGES SUGAR CANE GROWTH

The Climatology Department and the Physiology and Biochemistry Department are cooperating in several experiments pertaining to specific phases of the effect of climate on sugar cane. An experiment in which cane was grown under controlled temperature conditions has been harvested. Data from this experiment which are of particular interest are shown by the three curves in Figure 56. These data show that (1) the quality ratio remains nearly constant except when the cane was grown under a high day and night

temperature, (2) the weight of millable cane increases with temperature, and (3) the amount of sucrose increases with increased weight of stalk. For the conditions under which the cane was grown, an increase of 2 per cent in sugar was obtained for each increase of one degree of temperature provided flowering did not take place.

An important fact relating to cane growth, yield of sugar and tasseling has been brought out in this experiment. These canes were grown under six tem-

perature conditions, four of which were controlled, while the remaining two represented air conditions at Makiki and upper Manoa Valley. Of the six series, the canes grown under Makiki and Manoa conditions were the only canes that flowered; the Manoa canes flowered well in advance of the Makiki canes. The weight and sucrose produced per stalk for these two series were less for the temperature conditions under which they were grown than those in the other four series. This loss in weight and sucrose is attributed to the fact that the canes flowered, a condition which reduces both growth and sugar production. In sections B and C, these series are indicated with an X.

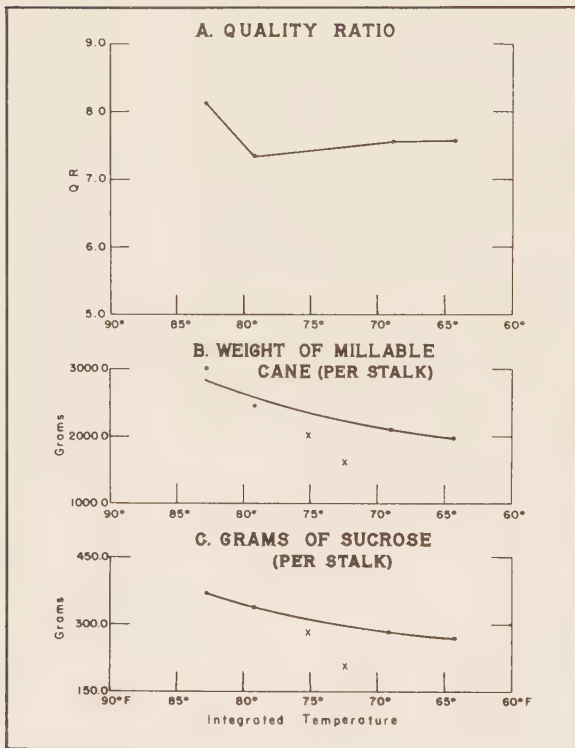
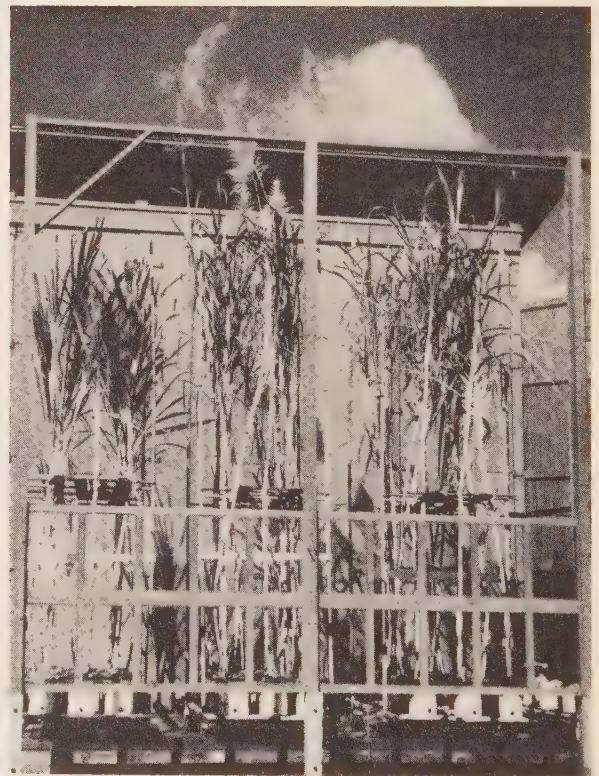


Figure 57. Flowering is very sensitive to climate. It is inhibited by either warm nights or cold nights; also by temperature continuously higher or lower than the Makiki temperature.

In addition to the effect on production of cane and sugar, the chemical analyses have brought out the following points:

- (1) Climate has striking effects on N distribution within the plant.
- (2) High temperature markedly lowers the values for sheath phosphate and, to a lesser extent, for potassium.
- (3) Phosphate seems to be unaffected by N level but potassium is somewhat lower in the low N plants.
- (4) The striking effect of temperature on flowering is shown in Figure 57.

Figure 56. Data from the experiment studying the control which temperature has on sugar cane growth are expressed in the three curves in this graph.



ARTIFICIAL CLOUDS INSTALLED AT MAKIKI

A new attack on climatic effects has been started this spring by the Departments of Climatology and Physiology and Biochemistry under the name of shading or cloud effects. A total of six plots, duplicating three N levels, is shown in Figure 58. The 10-foot by 20-foot adjustable vertical shades cut off direct sun from the cane for different periods each day. With

this arrangement, all other prevailing conditions of wind, air temperature and humidity are only slightly affected. On a clear day, the radiation intensity in the shadow is about 30 per cent of that in full sunshine.

Measurements of growth, plant chemistry and water consumption will be made.



Figure 58. Artificial cloud effects are created by shading plots for different times of the day with vertical walls which move upward with the growth of the cane.

GROWING CONDITIONS IMPROVED IN CURRENT YEAR

Growing conditions for the year ending August 31, 1951, as influenced by the two climatic factors of sunshine and temperature, were generally better than for the corresponding previous period. Data from five sunshine recording stations located at each of the Island Variety Stations show that during the year there were more hours of sunshine than were received during the previous year. Expressed as a percentage increase and presented in Figure 59, this amounted to 1.7 per cent for Maui, 4.5 for Oahu, 5.3 for the Hamakua coast area, 12 for the Hilo Coast area, and 15 for the Lihue area on Kauai.

The total solar radiation received this last year

at Makiki and Waipio as measured by recording pyrhemeters amounted to 195,387 and 189,579 gram calories per square centimeter, respectively (Figure 60). These figures represent high radiation values. High values have also been measured at all plantation photochemical stations.

The trend of maximum temperatures which started upward during the 1949-1950 period has continued upward during the 1950-1951 period ending August 31.

Data from all Variety Stations and most of the plantations show an increase in the number of day degrees (Figure 61).

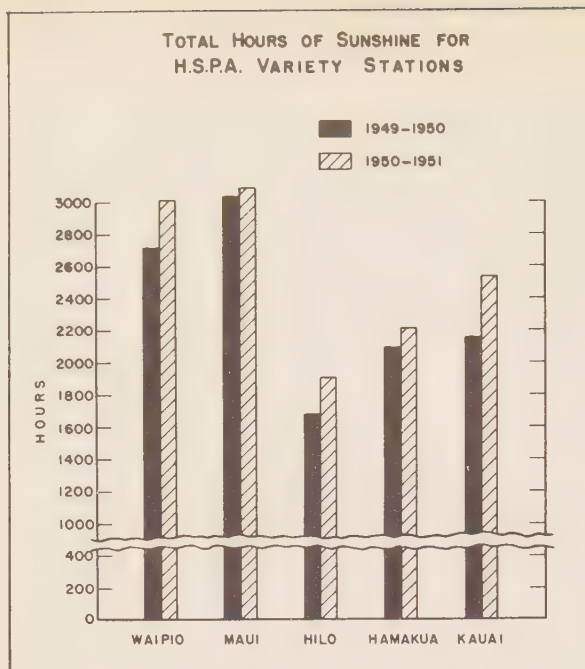
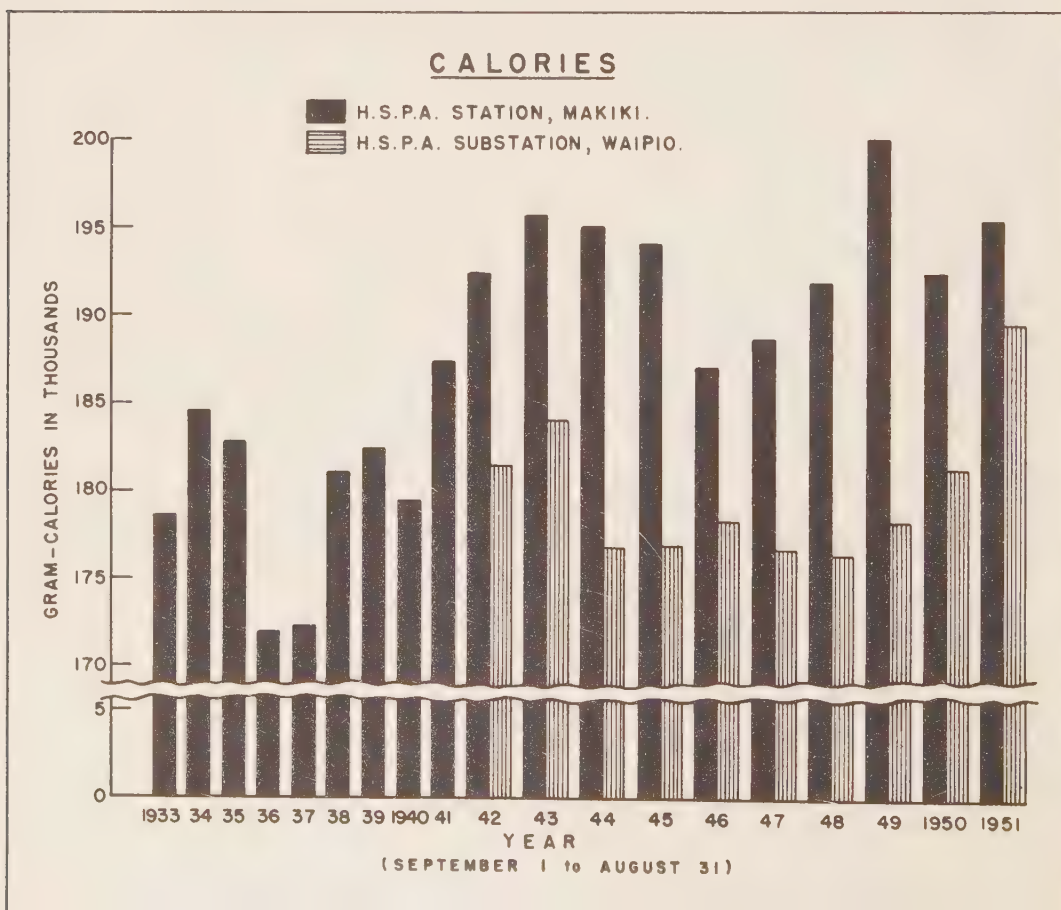
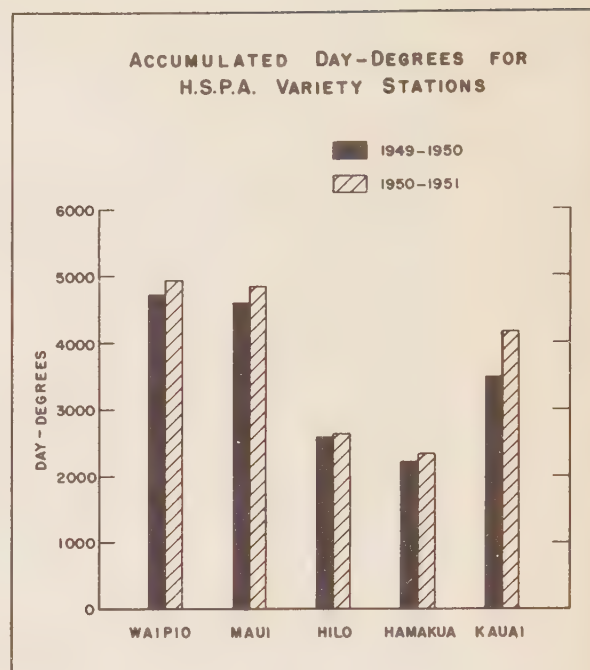


Figure 59. The year just past had more hours of sunshine than were received during the previous year.

Figure 60. (Below) This chart shows the high radiation values received at Makiki and Waipio.

Figure 61. (Right) Increase in accumulated day-degrees for Variety Stations.





WEED CONTROL

STRAIGHT CADE BECOMES PLANTATION PRACTICE

When standard CADE, produced by the homogenizers at pressure not exceeding 1500 pounds per square inch, is used without any dilution or additions, it is referred to as "straight" CADE.

Two Maui plantations have made the use of straight CADE standard practice in their weed control programs and, since straight CADE, particularly yellow CADE, seems to have pre-emergence as well as contact effects, they do not find it necessary to hoe their fields between applications. As a rule, four to

five treatments are all that are necessary before the cane closes in.

For the past year these two plantations have used no 2,4-D in regular field practice, and one of the two has dropped a former mixture which contained 2,4-D. Both plantations have used straight CADE for all herbicidal purposes.

Approximately 20,000 gallons of straight CADE are homogenized and applied daily by these two plantations.

NEW AROMATIC OILS PROMISING SUBSTITUTES FOR DIESEL OIL

Because of the heavy and increasing demand for Diesel oil, substitute oils for use in the production of CADE were developed by the Chemistry Department in cooperation with the California refineries of two oil companies. These new oils will cost no more than Diesel oil and will retain many of the aromatic constituents which are valuable for herbicides but

unsuitable for use in internal combustion engines.

Field tests have indicated that these new oils produce a yellow CADE which leaves a distinctive pattern on sprayed vegetation, is fully as effective as standard CADE, and is markedly superior to standard CADE in pre-emergence effect when applied to bare soil.

RESEARCH IMPROVES 2-7-R

Approximately 1½ million pounds of the combined emulsifying and wetting agent, 2-7-R, were used in the Territory last year. On a cooperative research and control project conducted by the Department of Chemistry with the manufacturer in California, improvements have been made in the manufacture of 2-7-R so that the free sodium sulfate in this alkyl aryl sulfonate has been reduced to less than one per cent. Unsulfonated oils have been eliminated

almost entirely and yet, in the modifications which have been made, the pH of the finished product has been brought to a value slightly on the acid side of neutrality. Laboratory tests are now being conducted in Honolulu on each batch of 2-7-R produced, as a specimen is rushed to this laboratory after each operation is completed and before the product is packaged for delivery to Hawaii. The entire production of this compound is used in the Territory.

E50—NEW EMULSIFYING AND WETTING AGENT FOR CADES

An intensive search has been made by the Department of Chemistry for a more satisfactory emulsifying agent to be used in the manufacture of a duplex CADE. Duplex CADE may be particularly useful in wet country where the killing action must be speeded up to the maximum for effective control of vigorous, tough, and prolific rain-nurtured weeds and grasses.

E50, an alkane emulsifying agent, is a soft, light, buff-colored paste, similar in appearance to 2-7-R paste. It may be purchased locally.

E50 is miscible with a given amount of water. In less than one hour of stirring, one drum of E50 paste (400 pounds) will form a solution with water and produce 228 gallons of a stock solution which is better and cheaper than any other compound of this type so far found for preparing CADE, for introducing its required wetting properties, and for processing Penite and Concentrate 40.

The molecule of E50 in a CADE or other emulsion is like a miniature dumbbell, one end of which attracts oil while the other end attracts water, and

which holds the combination tightly and toughly. This bonding of oil and water is so stable and persistent that it makes possible the development of a new series of more potent CADEs in which the added strength is divided between the oil and water phases of the emulsion. Up to the present, these results have not been achieved with any other emulsifier.

Research indicates that E50 can and should replace 2-7-R for all CADE work. An E50 prepared APC produces an excellent yellow CADE, whereas a 2-7-R prepared APC produces a yellow-type which at best is inferior in stability. E50 permits stepped up activation in the oil phase, but, more important still, E50 makes possible and practical an increased activation in the water phase superimposed on the already heightened potency in the oil phase.

E50 is not universal as a wetting agent, as is 2-7-R. For instance, it reacts with STCA, whereas 2-7-R tolerates it. A very satisfactory wetting agent for STCA solutions, even at high concentrations, is Santomerse 80.

SCREENING STUDIES WITH CMU

CMU, developed by the Du Pont Company, is proving itself an outstanding herbicide, both for pre-emergence control, and, when used in heavier applications, as a soil sterilant. (Figure 62.)

Under irrigated conditions, as much as four months of weed control have been given by a single application of four pounds of CMU per acre. Under unirrigated conditions, the control period has been approximately two months. Tests on *Panicum repens* on the island of Hawaii have shown effective control of growth but little actual kill from 40 to 80 pounds of CMU per acre. Damaging effects on cane have

been noted from applications in excess of eight pounds per acre when applied over the growing plants.

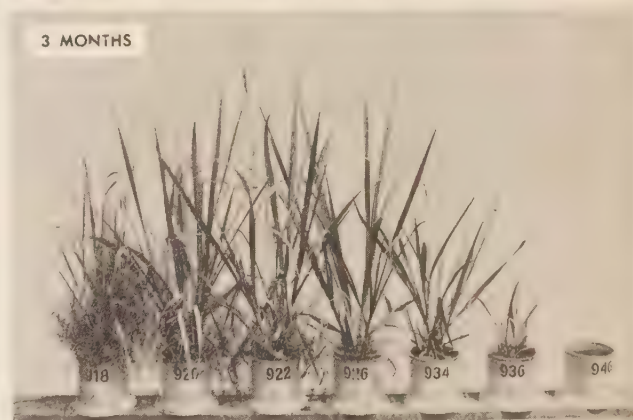
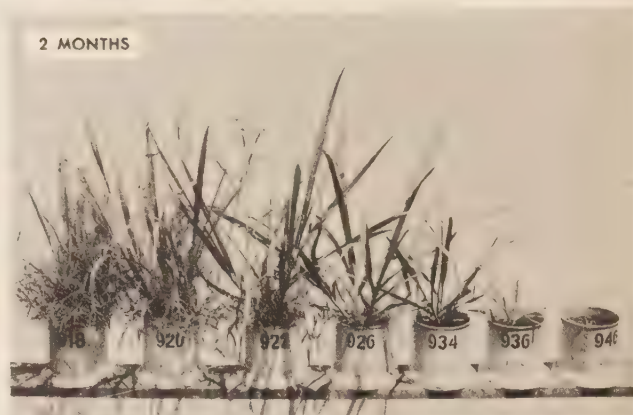
Arrangements have been made to have CMU processed into extrusion-type pellets for additional experimental study. It is believed that in pellet form, CMU could be put down uniformly, and that pellets containing heavier percentages of the herbicide might be advantageously applied by hand as a soil sterilant under flumes, along ditches, roadsides, and reservoir banks.

CMU + CADE is a recent development of the

Figure 62. CMU Experiment No. 1. For a pot study of CMU, installed on the Station grounds on May 4, 1951, one-eye seedpieces were planted about 3½ inches deep in each pot. Heavy applications of weed and grass seeds were worked into the soil surface of each pot. The left-hand pot in each series received no further treatment, but acted as a check against the actions of CMU. Into all the other pots, graduated doses of CMU were thoroughly blended with the top ¼ inch of soil. During the four months of the tests' duration, the pots were fertilized twice and were heavily irrigated every day. A point of interest is that at the end of four months heavy irrigation had not arrested the pre-emergence action of CMU, nor had it interfered with the sterilizing effect of the heavier treatments of CMU.

Observations made on comparable field tests indicate that 4 or 5 pounds per acre in the field are equivalent in observable effects to 2 pounds on the pot series.

The pencilled figures on the pots indicate pounds of herbicide applied per acre, i.e., 1 C is equal to one pound per acre.



Department of Chemistry and overcomes the difficulty of CMU's rapid settling in water suspension since the CMU is maintained evenly throughout the CADE emulsion, thereby insuring uniform application for several hours, or even days, after the com-

bination is prepared. The period of control given by this compound appears to be about the same as for CMU alone when used for pre-emergence. Weeds that have emerged at the time of application are killed by contact with the CADE.

FIELD TESTING

Field tests in 1951 have been aimed at evaluating chemicals that can be substituted for 2,4-D spray in order to overcome the serious effects of spray drift. Attention has been given to the testing of different forms of CADE, activated oil, and straight oil, to

substitute for arsenicals as effective contact sprays.

More than 50 field tests have been carried out cooperatively between plantations, Island Representatives, and the Department of Agronomy, and the resulting data have been sent to the plantations.

SUMMARY OF FIELD TESTS ON 2,4-D PELLETS

Agronomists and chemists have felt that if 2,4-D could be successfully applied in pellet form, its most objectionable characteristic might be removed.

So field tests were made with three types of 2,4-D pellets: extruded clay, graded lava cinders, and diatomaceous earth fragments. The first two proved about equally effective, both were superior to the third and can be obtained from local distributors. The Departments of Chemistry and Agronomy feel that the 2,4-D pellets can be recommended for field scale tests, and that volume use of the pellets will reduce their present high cost.

The following observations resulted from the tests:

1. The main reason for putting 2,4-D into pellets is to reduce the possibility of damage by drift to vegetation near fields being treated. Aircraft tests have shown that under wind conditions up to 15 miles per hour, the pellets have all come down within 100 feet of the edge of the application swath, with only a few found beyond 50 feet.

2. In early tests, some 2,4-D dust came off the pellets, but recent tests show that this weakness has been nearly eliminated, and that there appears to be no serious risk in using the 2,4-D pellets as now formulated. It is advisable at present, however, to con-

duct tests at a safe distance (at least 500 feet) from sensitive vegetation.

3. Following the application of pellets, moisture in the form of rain or irrigation water is necessary to release the 2,4-D to the surface soil. Poor results follow an extended dry soil period, but under irrigated and moderate-to-high rainfall, the control has usually proved to be nearly as effective as that given by 2,4-D spray at the same dosage per acre.

4. 2,4-D in pellet form is effective only for pre-emergence control of weeds. Timing of application is, therefore, of extreme importance, since weeds that have emerged or that appear after application must be spot-sprayed with contact herbicide or spot-weeded by hand.

5. No appreciable gain in the period of effective control has been shown by increasing the dosage of 2,4-D applied in pellets. The 2,4-D is released from the pellets in a very few days when adequate moisture is present.

6. Murrayair, Limited, at Honolulu Airport, is prepared to apply the pellets from a duster plane which has been calibrated for application of 30 pounds of pellets (3 pounds 2,4-D) per acre, but which can also make heavier applications.

SES—A NON-HORMONE SUBSTITUTE FOR 2,4-D

SES is a comparatively new chemical development, consisting of the sodium salt of dichlorophenoxy ethyl sulfate. Up to the present time it has been manufactured only by pilot plant, but production on a large scale is scheduled to begin in the fall of this year. The price of this compound is somewhat less

than one-half its original cost and after commercial production has been attained, it will probably reach a figure comparable to the cost of 2,4-D acid.

SES does not contain any 2,4-D and, contrary to advices given by the manufacturer's chemist last year, it does not revert to 2,4-D in contact with the soil.

It may be applied as a solution either from land-operated equipment or from a plane for pre-emergence treatments of soil which is free of any grass or weed growth. Drift of SES spray solution to any above-ground type of vegetation, whether or not it be sensitive to 2,4-D, does not appear to induce the epinastic and other seriously damaging effects which result from similar contamination with 2,4-D. In contact with soil, SES functions in an identical manner to 2,4-D in repressing or preventing the germination of weed and grass seed for a limited period of time. Upon contact with the soil, SES undergoes a rapid change in composition wherein the sodium ethyl portion of the side chain reverts to an alcohol-type of compound, which apparently accounts for its pre-emergence value.

Field tests have suggested the following conclusions on the effectiveness of SES:

1. Although SES has not proven itself entirely equal pound for pound on the active percentage basis with 2,4-D, it has come close enough to warrant its

use when it becomes available in quantity.

2. Tests with concentrations of up to 1000 parts per million of SES have shown no serious effect on papaya or tomato plants.

3. Young seedling weeds have been destroyed by contact effect of SES and it is possible that with proper timing some contact effect might be realized on a field scale. However, SES should not be depended upon as a contact spray, and, due to some contact effect from SES, it should be used with discretion in spraying over growing cane.

4. The toxicity of SES to humans is so low that it is not considered a hazard to spray operators.

5. Formulations have been developed by the Department of Chemistry whereby SES can be used in combination with other herbicides such as CADE and TCA. SES + CADE is useful as a replacement for 2,4-D + CADE in areas of drift hazard. It is slightly less effective than equal concentrations of 2,4-D + CADE.

MCP—THE ENGLISH COUNTERPART OF 2,4-D

MCP was developed in Great Britain about two years ago. It was originally synthesized from toluol, but at the present time it is being manufactured in the United States from a by-product of coke ovens operated by the mainland steel industry. Thus, its manufacture requires no benzole and half the amount of chlorine needed for the production of 2,4-D.

According to reports from mainland research groups, MCP is somewhat superior to 2,4-D in repressing the germination of grasses, and has a more lasting effect. It may be processed into a Honocide-type of concentrate whereby it will carry 2½ pounds

or more of the chemical per gallon of water solution, whereas Honocide carries ⅓ pound of 2,4-D per gallon. Therefore, the possibilities of employing this new chemical as a substitute for Honocide in plantation mixing plants appear to be very promising. At present, MCP is being manufactured on a pilot plant basis. Because it does not require benzole in its synthesis, expansion to full-scale commercial production may follow without much urging.

Field tests show that MCP is closely related to 2,4-D, equal dosages of either giving the same degree of control.

TESTS PROVE CADE + SSA EFFECTIVE

A comparative study was made of CADE + SSA in water dilutions. Equal applications in gallons per acre of straight CADE, CADE 1 in 2, CADE 1 in 4, and CADE 1 in 8, with one-half portion of SSA (stock solution activator) in the latter three, were compared. Photographs were taken before treatment,

15 minutes after treatment, and 24 hours after treatment, of wiregrass and red pualele. In all cases, the extent of kill was equal at the 24 hour point. Both straight CADE and diluted CADE have proven superior to Concentrate 40 in several tests made on the Hilo Coast.

TCA PROVES VALUABLE FOR CONTROLLING GRASSES

The great value of TCA is as a grass killer when it is applied over the foliage as a contact spray, and

when some of the spray falls on the ground to be absorbed by the roots. It has been shown that both

means of intake by the plant are necessary for maximum effect.

A study of the tests made with TCA for pre-emergence control of a broad population of weed species shows that TCA must be applied at two to four times the dosage of 2,4-D in order to give satisfactory pre-emergence control.

In using 2-7-R as a wetting agent in TCA solutions, it has been found that the best results may be obtained by adding a solution of 2-7-R either to the diluted TCA solution when it is ready for application in the field, or to the water used in making such a solution before the chemical is added and dissolved.

Many plantation men wishing to by-pass the complications entailed in working 2-7-R into the solution just prior to application, have hoped that all processing might be done ahead of time, so that dilution with water would be the only step necessary in the field. A formula, worked out by the Chemistry

Department and released to the plantations, gives promise of answering this request in an entirely satisfactory manner.

Specific field tests conducted during 1951 show that:

TCA + 2,4-D has proven very effective where pernicious grasses persist. The TCA acts mainly on the grasses and the 2,4-D on broad-leaved plants when applied as a contact spray. The TCA and 2,4-D supplement one another as a pre-emergence control against further weed emergence for an indefinite period.

TCA + 2,4-D + CADE is of value where increased contact effect is desired, but at an increase in cost.

TCA + CADE has proven effective in facilitating the entry of TCA into the above-ground portions of plants, thereby hastening the effect and apparently giving increased effectiveness over TCA alone.

SPECIES REACT DIFFERENTLY TO 2,4-D AND TCA

During the last few years, the tests conducted with 2,4-D and TCA have determined a general pattern of control over many of the weed species found in sugar cane fields. Based on tests and a backlog of experience in the use of 2,4-D and TCA, ratings of the degree of species importance and their reactions to both 2,4-D and TCA applied either as contact or pre-emergence sprays, were assembled, put in table form,

and presented to all the plantations.

It must be pointed out that, due to varying factors, the reaction of any species to any chemical will vary to some degree. The reactions shown in the table will, however, constitute a generally reliable guide. Many species have not as yet been included, but the scope of the study will broaden as accurate information is obtained.

INHIBITOR OF CORROSION BY TCA PERFECTED

Two or more manufacturers of sodium TCA are including small amounts of sodium chromate in their product, as recommended to the plantations by the Department of Chemistry. As an inhibitor of corrosion on metal and equipment by this very destructive compound, sodium chromate appears to be giving general satisfaction, particularly in the case of aluminum. Plantation men report that when fortified with

sodium chromate, the sodium TCA dissolves more rapidly and apparently produces a more stable solution.

There does not appear to be any likelihood that this chemical will become scarce or in short supply since at least six different manufacturers are producing it and marketing it generally throughout the mainland and in Hawaii on a competitive basis.

PROCESS OIL-SOLUBLE FORM OF ACTIVATOR AND SAVE MONEY

The oil-soluble form of the HSPA Activator is now readily available on the market, while the water-soluble form is still tight. The sugar industry of Hawaii is insured an ample supply of activator if the larger users will take advantage of the four cent saving in the cost of the chemical by processing the oil-

soluble form to the water-soluble form on the plantations. Details for carrying on this work, as well as for making the aqueous portion of CADE (APC) and the SSA directly from OSA without going through the initial conversion process, have been sent to the plantations.

NEW SPRAY EQUIPMENT DEVELOPED DURING 1951

Information on all developments made during the past year on spray equipment has been released to all the plantations, and includes full data on a new pres-

sure tank, with testing and repair procedures approved by the safety engineers for all agencies and plantations.

A COOPERATIVE ATTACK ON WOODY PLANT CONTROL

A project of cooperative woody plant control studies was organized in 1950 by the Agronomy Departments of the University of Hawaii and of this Station, and by the Pacific Chemical and Fertilizer Company. The information obtained regarding methods of controlling trees and shrubs under the various climatic conditions found throughout the Territory of Hawaii has been compiled for the use of ranchers and plantation-ranch operators who wish to clear certain areas in order to ensure greater production of grass on range and pasture land.

Since utility companies have the somewhat paral-

lel problem of keeping power lines, water lines, and trail areas open, they are included in the project.

Experimental studies on a new formulation, described by the Department of Chemistry as "Three-Hormone Tree Killer", have been rather encouraging. The concentrated stock solution consists of a mixture of 2,4-D, 2,4,5-T, and TCA (Figure 63). An oil-soluble emulsifying agent has been added to facilitate absorption with the sap of the tree or bush under treatment, and to render the compound miscible with water for use when dilution with Diesel oil is undesirable or impracticable.



Figure 63. Proliferation of tissue along part of the trunk shows the effect of 2,4-D + 2,4,5-T as a basal spray on guava. The tree is dead by the end of three or four months.

EFFECTS OF 2,4-D ON WOODY PLANTS STUDIED

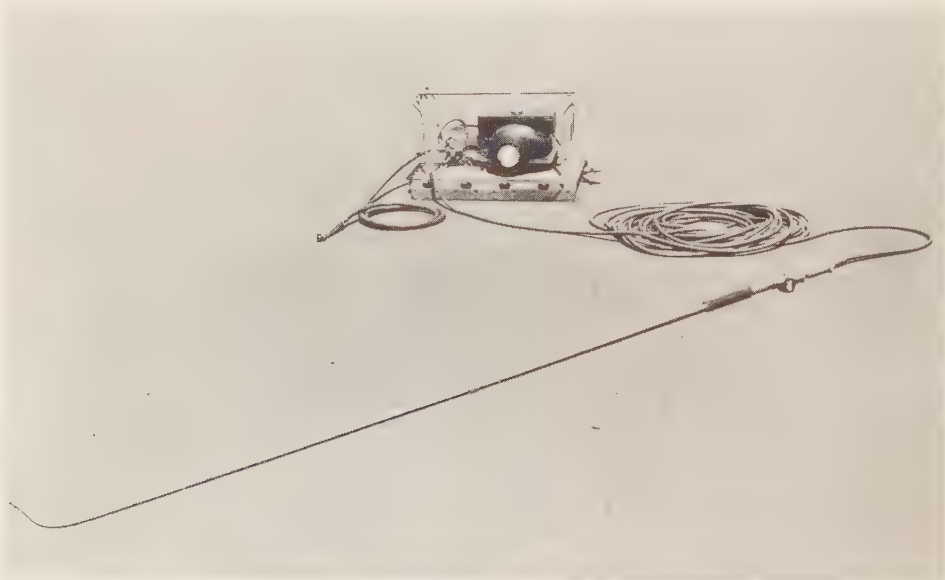
Tests conducted on several islands have classified the sensitivity of many species of woody plants and trees to 2,4-D used both as a foliage application and as a basal spray around the lower portion of the trunk. (Figures 64 and 65.)

Obviously, the reaction of each species to treatment will depend on multiple factors, such as different conditions of soil and weather which will inevitably cause some variation in results obtained, but it is believed that, on the whole, the data accumulated will prove helpful.

This classification of species sensitivity to 2,4-D will be included in a publication made jointly by the University of Hawaii and this Station.

Figure 64. The hoseline of the spray gun connects with a pumping unit. The spray gun consists of a strainer, valve, pressure gauge, and pipe to the nozzle which is Spraying Systems Teejet with TG 2 solid cone tip. The operator is spraying stumps of woody plants with 2,4-D.

Figure 65. This portable power sprayer consists of a small engine and gear pump with 100 feet of 1/4 inch plastic hose, and a spray gun which includes a 6-foot aluminum pipe with a 9502 tip in Spraying Systems Teejet nozzle. The gun is also equipped with a strainer, valve and pressure gauge.



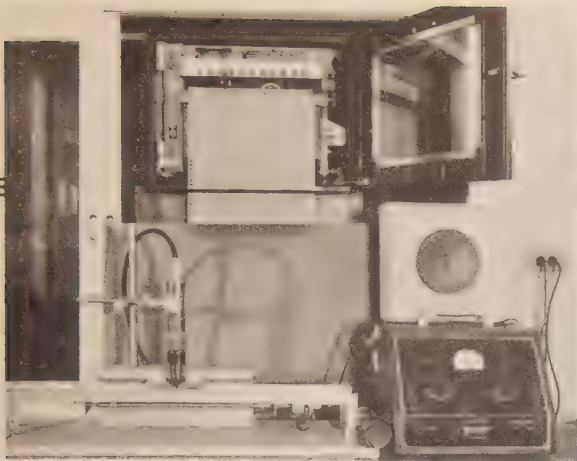


Figure 66. Recording machine for paper chromatography.



Figure 67. Damage to cane by rats at Grove Farm.

MISCELLANEOUS

ADVANCES IN BIOCHEMICAL ANALYSIS

A new reagent, 2,3,5-triphenyltetrazolium chloride, has been developed into a quantitative method for fructose in the presence of glucose and sucrose. This represents an important advance in the field of sugar analysis.

An old qualitative test for aconitic acid has been developed into a quantitative method. This is a colorimetric procedure, much more rapid and less time consuming than the standard method. It also has the advantage that it is a micromethod which makes it possible to follow aconitic acid metabolism in a small amount of leaf tissue.

Paper chromatography has been adopted as a standard procedure for separating microquantities of sugars, organic acids and other tissue constituents. For the first time, glucose can be completely separated from fructose in the amounts present in a leaf punch. When these are radioactive, they can be measured on the paper with a Geiger counter. A recording machine has been developed for automatically scanning the paper and finding the position and quantity of the unknown on the chromatograph. Figure 66 shows the component parts assembled for this work.

RAT CONTROL INVESTIGATIONS

Warfarin (Compound 42) has been rapidly gaining favor with the general public during the past year. The success of this new poison is entirely dependent on the cumulative effect of small doses ingested over 5 to 10 days. In such low concentration (1-4000), the poison is not detected by the rats and no bait shyness has developed in any of the tests. (Figure 67.)

Four or five days after the rats discover and begin eating this new food at the feeding stations, they begin to die, and this killing process can go on as long as bait is present and new rats appear.

Generally speaking, rats ate an average of 36.3 per cent of their body weight of the Warfarin rolled

oat mixture, and lived an average of 6.2 days after their first meal of the poison.

The addition of 0.3 per cent of para-nitrophenol to the bait to prevent molding has made frequent inspection visits unnecessary.

Warfarin will be especially useful around plantation homes where safety from accidental poisoning is a prime consideration. The low concentration of the chemical in the final cereal bait provides a safety factor for man and for domestic animals, because the chance that a single dose could be serious or fatal is very remote. This safety factor is available in no other effective rat poison. (For further details see the Hawaiian Planters' Record, Vol LIV, No. 1.)



Figure 68. Trainees in Sugar Factory Technology. From left to right: Edwin T. Ogasawara, Henry K. Higashiyama, Yukio Omiya, William D. Fairchild.

TRAINING PLANTATION PERSONNEL

Figure 69. Trainees in Agriculture. From left to right, front row: Charles W. May, Jr., Robert T. Vorfeld, K. Lyman Bond, James A. Silva, Yasuhiko Kawawaki. Back row: Wallace L. Doty, Ian W. Bowman, Charles T. Wallis, Russell S. Robinson, Ernest W. Spencer, Edwin W. Neumann.



